SCIENCE

12 May 1961

Vol. 133, No. 3463

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

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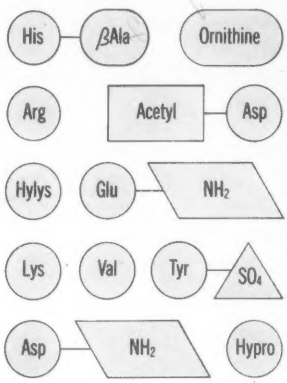
Amino acid analysis

...quantitative analysis in 24 hours for the twenty amino acids in protein hydrolyzates... in 50 hours for the free amino acids and related compounds in physiological fluids.

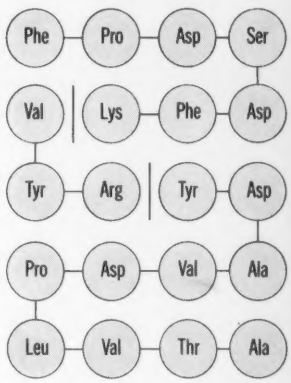
Amino acid isolation

...separation, collection, and identification of amino acids and related compounds in physiological fluids and tissue and plant extracts on both analytical and preparative scale.



Peptide isolation

...separation, collection, and identification of peptides on both analytical and preparative scale.



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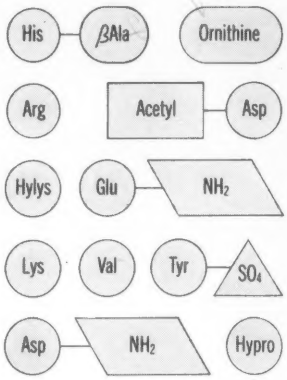

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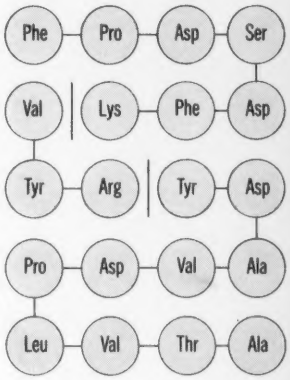
... separation, collection, and identification of peptides on both analytical and preparative scale.



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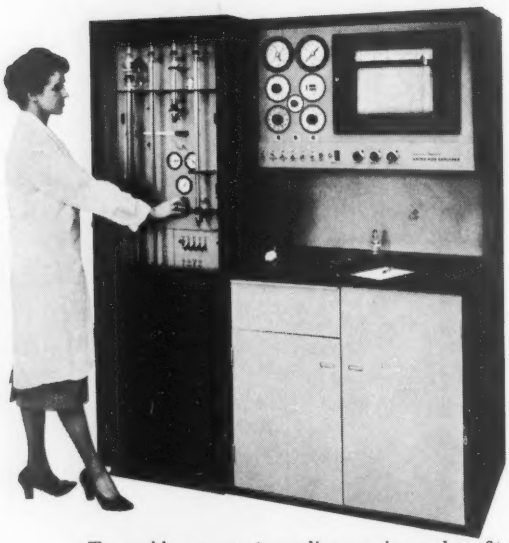

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Cover Generation of an aerosol. The particles are formed at the edge of a spinning disk by shearing action and centrifugal force on the fluid. The fluid is fed onto the disk with a hypodermic needle (right). [William F. Hetrick and John N. Schutz, Naval Biological Laboratory, School of Public Health, University of California, Berkeley]

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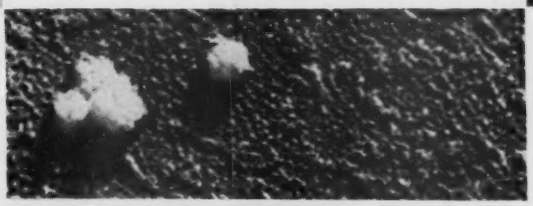

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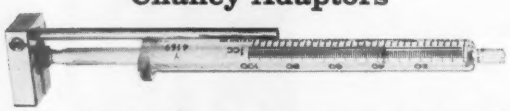

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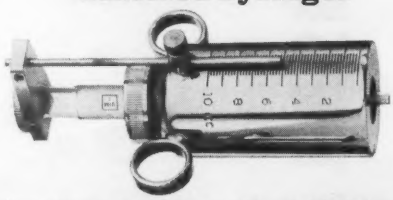

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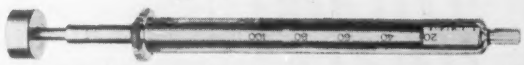

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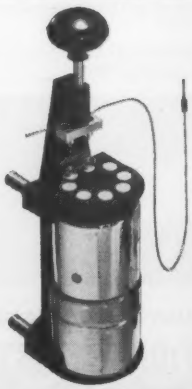

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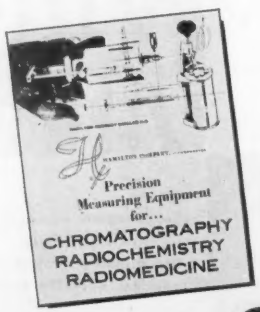

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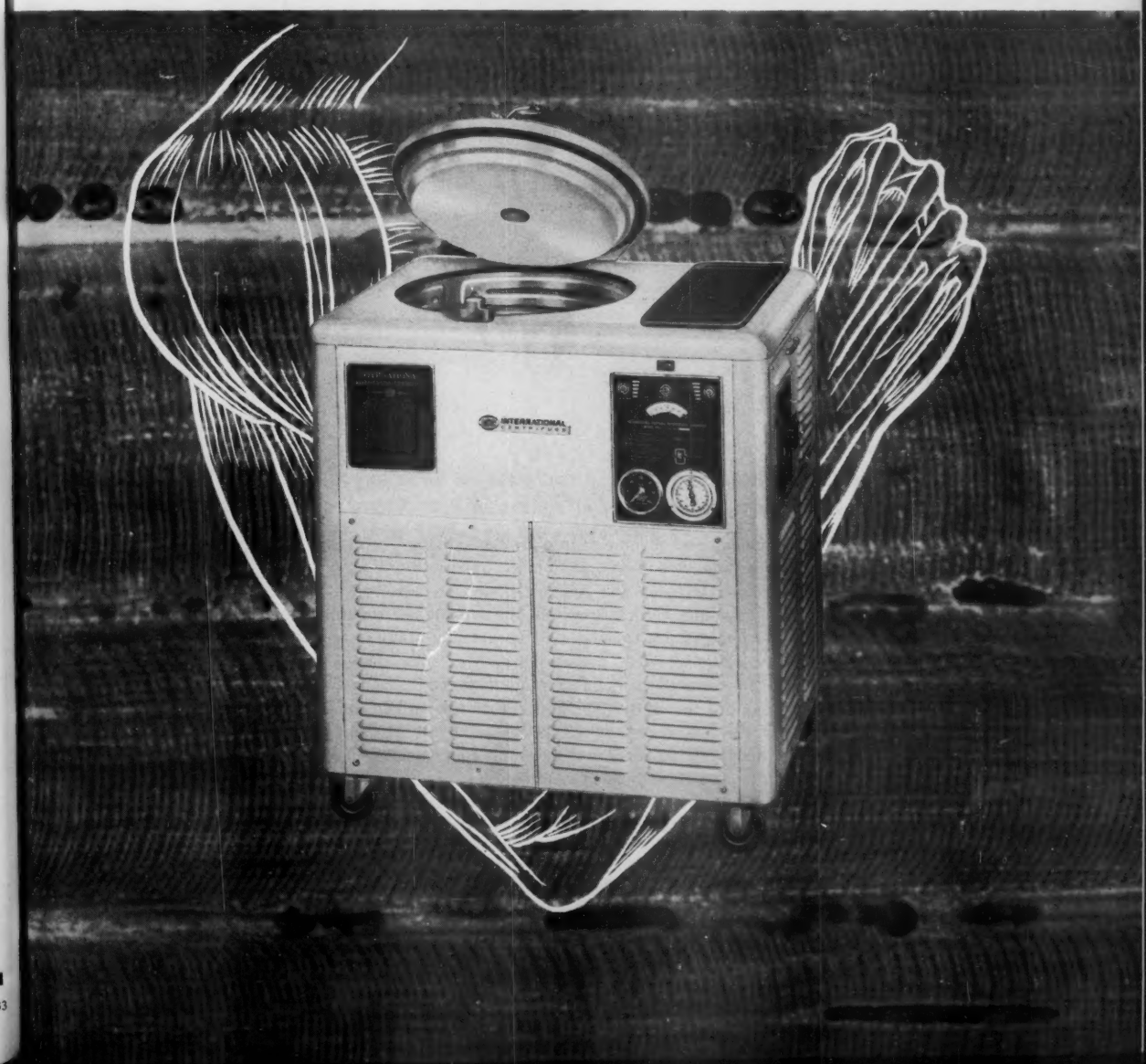

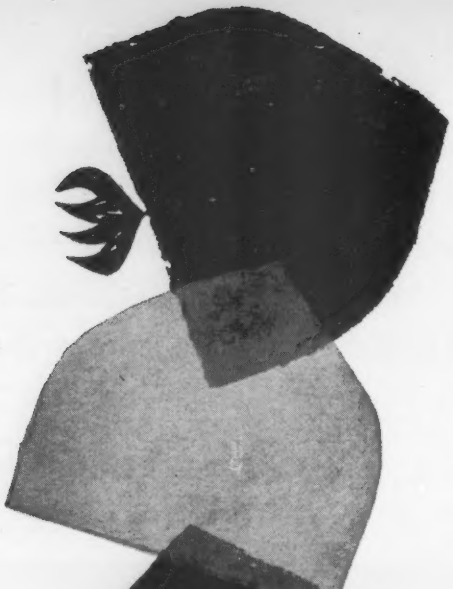

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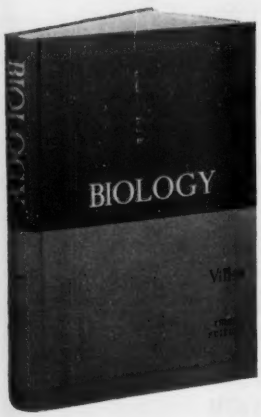

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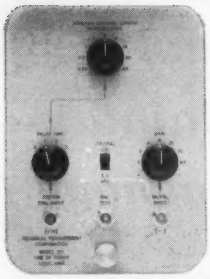

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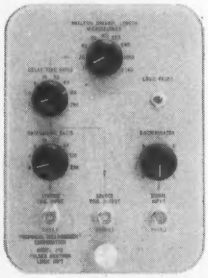

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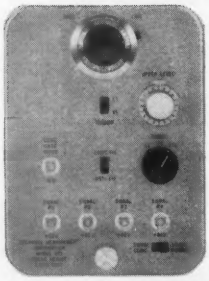

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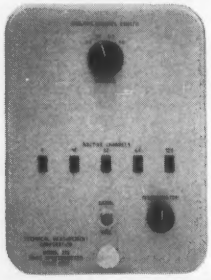

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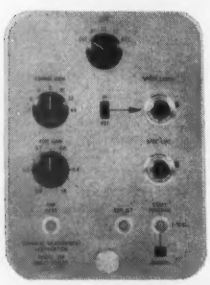

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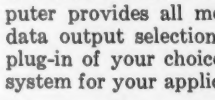

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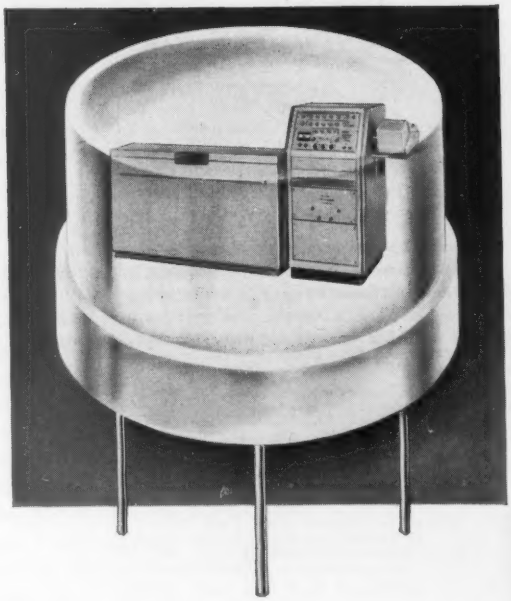

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CURRENT PROBLEMS IN RESEARCH

The Earth's Crust and Upper Mantle

New geophysical methods are beginning to reveal essential details about the earth's outer layers.

Frank Press

An international scientific effort called the "Upper Mantle Project" is being organized by the International Geophysics Committee to stimulate and coordinate studies of the outer layers of the earth. Such a program is particularly appropriate at this time. Some of the major features of the crust and upper mantle have been revealed, and the technology of geophysical exploration has advanced to the point where the essential details can be obtained. Until more is known about the crust and upper mantle, such basic geological problems as the origin of continents and ocean basins, the nature of orogeny and volcanism, and the mechanism of earthquakes will remain unsolved.

The principal tools for exploring the outermost few hundred kilometers are seismological and gravitational ones. Earthquakes and explosions are the sources of seismic energy, and portable as well as permanently installed seismological stations produce the data. Gravity exploration is carried out by means of sensitive gravimeters, which can now operate on sea and land with the precision required for this type of research (about $10^{-6}g$). These methods and the results which have been obtained to date are described here. Some unsolved problems and the methods for attacking them are then discussed.

Seismological Methods and Results

At best, seismological methods reveal the mechanism at the earthquake focus and the variation of elastic velocities with depth. It is only by comparison with laboratory measurements, on rocks, of elastic parameters as functions of temperature and pressure that we can infer which rocks occur at depth. Laboratory results for compressional velocity in granite and gabbro under conditions of pressure and temperature likely to occur in the crust (*1*) are shown in Fig. 1.

Almost 50 years have passed since Mohorovičić first demonstrated that the structure of the earth's outer layers can be deduced from the travel times of refracted seismic waves. His method may be understood from Fig. 2. A source of elastic waves (earthquakes in the early work, explosions in modern methods) radiates energy in all directions. Among the many possible paths available to the waves are three shown in the schematic model of the crust. Waves traversing these paths are characterized by straight-line travel-time curves whose slopes are the reciprocal of the velocities a_i in the corresponding layers and whose intercepts T_i provide the additional information needed to compute layer thicknesses. Appropriate formulas and methods for dealing with complications such as dipping interfaces and velocity inversions may be found in standard textbooks of geophysics.

Field methods consist in recording and timing seismic waves along lines extending from the source, with a sufficient number of observations to determine the travel-time curves. The technique for oceanic investigations differs in that ships are used to detonate explosions and record the sound waves. Either radar or the travel time of sound in water is used to determine the separation between the detonating and the receiving ship, the instant of explosion being transmitted by radio. It is common for both ships to "shoot" and "record," so that the reversed profiles necessary to determine the dip of interfaces can be efficiently obtained. Whereas several hundred to several thousand pounds of explosives are needed for land observations, oceanic observations can be achieved with charges of 300 pounds or less. The "breakthrough" which made oceanic studies feasible was the demonstration by M. Ewing and his co-workers that near-surface explosions and pressure-sensitive detectors are adequate for recording subcrustal refractions.

As a result of the efforts of many investigators in different countries it is possible to make some statements about crustal structure under the continental shields and the ocean basins (Fig. 3). The Mohorovičić discontinuity, which separates the light, silicic crust from the heavier, ultramafic mantle, occurs at a depth of about 35 kilometers under the continental shield areas and about 10 kilometers below sea level in the ocean basins. This fact, together with the known increase in Bouguer gravity from continent to ocean, conclusively demonstrates isostasy as a basic tectonic mechanism on the continental scale (*2*). The continental crustal layer below surficial sediments and uncom-

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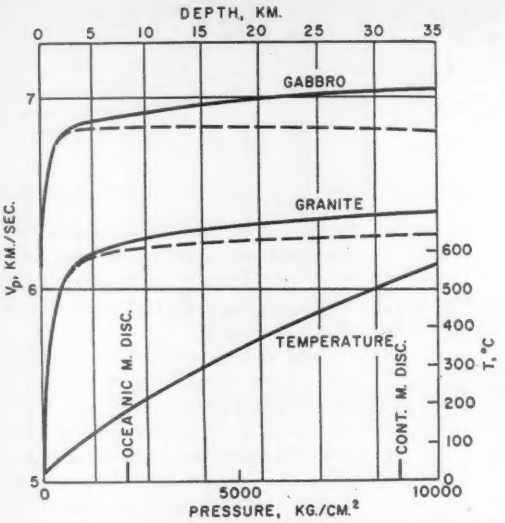


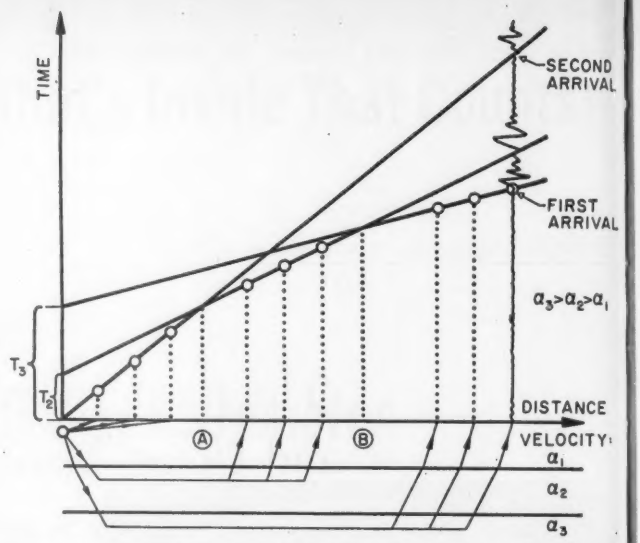


Fig. 1 (left). Changes, with increases in pressure and temperature, in compressional wave velocity in rocks in the continental crust. Solid line, effect of pressure only; dashed line, effects of pressure and temperature combined. Depth and pressure at Mohorovičić discontinuity (M. disc) under oceans and continents is indicated. [After Birch (*1*)] Fig. 2 (right). Schematic diagram of seismic refraction paths in a layered crust underlain by the mantle.

pacted crystalline rocks is characterized by compressional and shear velocities of 6.0 to 6.2 kilometers per second, and of 3.5 to 3.6 kilometers per second in the upper part. These velocities are consistent with findings for granite under pressures equivalent to those found at depths of several kilometers (*1*).

The crustal layer beneath the ocean basins consists of unconsolidated deep-sea sediments a few hundred meters thick, underlain by a layer of mafic rock, with compressional velocity of 6.5 to 7 kilometers per second. Some investigators report a thin layer of compacted sediments or volcanics between the unconsolidated sediments and the mafic rocks. Detailed information about layering in the sediments must await measurement with detectors placed on the sea floor.

The mantle beneath continents and ocean basins is characterized uniformly by compressional velocities of 8 to 8.2 kilometers per second. Shear velocity under continents is 4.6 to 4.8 kilometers per second. No information on shear velocity is available for the suboceanic mantle. These velocities are consistent with a mantle composed of rocks similar to dunite (*1*).

The older notion that elastic velocity increases with depth below the Mohorovičić discontinuity has been abandoned. Gutenberg's observation (*3*) of a shadow zone for earthquake-generated elastic waves led him to postulate the existence of a "low"-velocity layer. Amplitudes of seismic waves from earthquakes show much variability, and the more precise amplitude data obtainable from nuclear explosions (*4*) were required to substantiate the existence of the Gutenberg shadow zone and low velocity region. Figure 4, modified from a figure in Romney's paper (*4*), shows the amplitude variation of compressional waves from the underground nuclear explosions Blanca and Logan. The rapid decrease in amplitude with distance to 1500 kilometers indicates that seismic energy enters this zone by diffraction and not by following geometric paths—a consequence of the decrease in velocity below the Mohorovičić discontinuity. As shown below, surface-wave data offer independent verification and enable us to specify some details of the low-velocity zone. It is of interest that the shadow zone poses a major difficulty in the detection of small nuclear explosions.

Now that these basic features of the crust and upper mantle are understood, geophysicists are turning their attention to the finer details, which are also the crucial details of crustal structure. It is important to know about variations of elastic parameters with depth in the crust. Does the Conrad discontinuity, which separates the crust into two layers, exist? And does it occur uniformly under the continents? Isostasy on a continental scale has been demonstrated. What is the mechanism of compensation of regional topographic highs? How does the continental crust merge with the oceanic crust? Is the contact between crust and mantle an abrupt discontinuity, or is there a zone of gra-

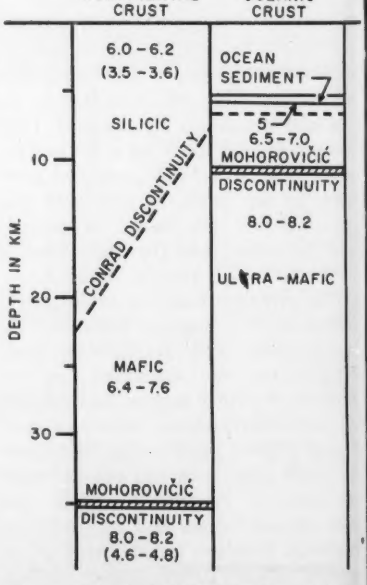


Fig. 3. Seismic indications of crustal layering in continental shields and ocean basins. Compressional and shear velocities (in kilometers per second) are shown. Shear velocities are in parentheses.

dation? Is the mantle a more dense phase of crustal rock, or does the observed difference represent a change in composition? What is the significance of the low-velocity zone in the upper mantle? Does it occur uniformly under continents and oceans? These are some of the basic questions currently faced by geophysicists—questions which can be answered only through refinement of old methods and use of new methods. A review of some of the newer techniques and the results which have been achieved follows.

Correlation Refraction Shooting

The intermediate layer depicted in Fig. 2 is inherently difficult to observe. Detectors located in the limited range between positions A and B record waves refracted from this layer as "first arrivals." A slight increase in T_2 with respect to T_3 is sufficient to "mask" this layer so that waves refracted from it occur only as "second and third arrivals." It is difficult to identify refracted waves occurring as later arrivals because of the reverberation initiated by the first arrivals. Fortunately, there is often sufficient coherence and character in later-arriving refracted waves that these waves can be identified by correlation across an array of detectors extending along a line extending 1 or 2 kilometers (Fig. 5). This technique of correlation, familiar to petroleum geophysicists, has been successfully applied in crustal investigations by Gamburtsev and his colleagues (*5*), and is called the DSS method. It is to the credit of these workers that they have developed a seismic detection system of high sensitivity and of frequency response such that relatively small explosions are sufficient to complete a profile. Veytsman, Kosminskaya, and Riznichenko (*5*) report that both the Conrad and the Mohorovičić discontinuity have been mapped by this method in regions of complex structure. They report, for example, that the crustal thickness increases to as much as 53 kilometers under the northern Tien Shan Mountains. Compensation for high topography occurs by a mechanism which involves increased depths of the Mohorovičić discontinuity, the Conrad discontinuity behaving in a complicated fashion, sometimes discordant with the former. Typically, however, the intermediate (basaltic) layer is thicker under uplifted areas.

In the United States, correlation methods have been applied by Woollard, Meyer, and Steinhart (*6*), and by Aldrich and Tuve. In the midcontinent region these investigators found normal crustal thickness (35 to 40 kilometers), with evidence which favored the presence of the Conrad discontinuity at a depth of about 15 kilometers. On the eastern flank of the Rocky Mountains a crustal thickness of 50 to 55 kilometers was found, with evidence of three crustal layers with velocities (in kilometers per second) and thicknesses (in kilometers) as follows: (i) velocity, 6.08; thickness, 15 to 20; (ii) velocity, 6.97; thickness, 17; and (iii) velocity, 7.58; thickness, 10 to 20.

It is still too early to generalize from these newer results. Some common features are apparent, but differences occur which may be unreal and related to differences in method of interpretation. The presence of the intermediate (basaltic) layer is widely accepted, although the velocity in this layer shows great and possibly real variability (from 6.4 to 7.6 km/sec). Crustal thickening under major uplifts seems to occur generally. Exceptions which have been reported may be due to masking of the intermediate layer or to mistaking the Conrad for the Mohorovičić discontinuity. When the intermediate layer occurs with velocities of 7.6 kilometers per second the question arises as to which interface separates the crust from the mantle. When more correlated refraction experiments have been made and when common interpretive procedures have been established under the aegis of the Upper Mantle Project, then more meaningful evaluation and generalization will be possible.

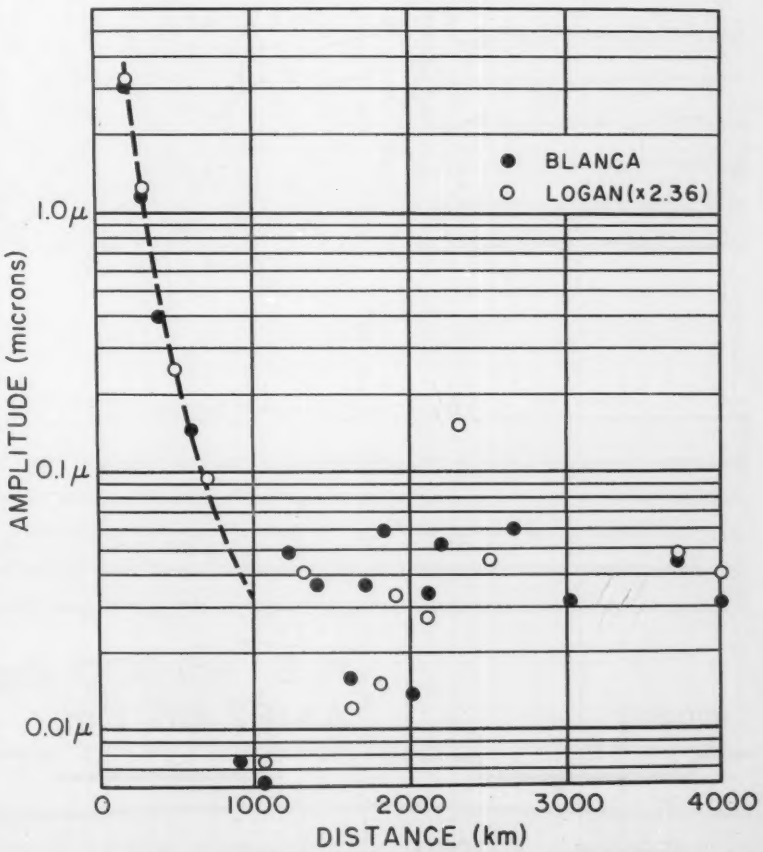


Fig. 4. Amplitude of compressional waves from underground nuclear explosions in Nevada. The rapid decrease in amplitude between 300 and 1500 kilometers defines the shadow zone. [After Romney (*4*)]

Surface Wave Methods

Propagation of seismic surface waves over the earth occurs in the wave guide formed by the free surface, the ocean (for oceanic paths), the crustal layers, and the velocity gradients in the mantle. The wave guide is dispersive because the longer the wave, the greater the depth of penetration. Thus, the initial seismic transient undergoes phase and amplitude distortion during propagation to form a long train of waves. With the advent of high-speed computers and sensitive, long-period seismographs, much progress has been made in deducing the properties of the wave guide (that is, the structure of crust and mantle) from an analysis of the phase distortion.

Two methods of analysis are available. The variation of group velocity with frequency can be obtained from seismograms, if the time of origin and the location of the seismic source are known. Group-velocity dispersion is controlled by the structure of the crust and mantle between epicenter and seismograph. Phase velocity is obtained from an array of at least three seismographs and is sensitive to structure beneath the array. Only relative times at each station are required to derive phase velocity. Figure 6 shows three seismograms (aligned with respect to time) from a triangular array of California stations approximately 100 kilometers apart. These are records of Rayleigh waves from a distant Pacific Ocean earthquake. Note the increase in frequency of the waves with increasing time—an increase which is controlled by the group velocity dispersion. The time required for a given crest or trough to cross the array depends on the phase velocity.

Figure 7 shows the observed curve for group-velocity dispersion of Rayleigh waves for the period range 10 to 400 seconds (*7*). Between 10 and 100 seconds, two curves are observed, one for the oceanic crust, the other for the continental crust. Beyond 100 seconds the two curves merge into a single curve, indicating that for these more deeply penetrating, longer waves the upper mantle controls the dispersion. Observed curves for dispersion are interpreted by computing theoretical curves for various models and selecting

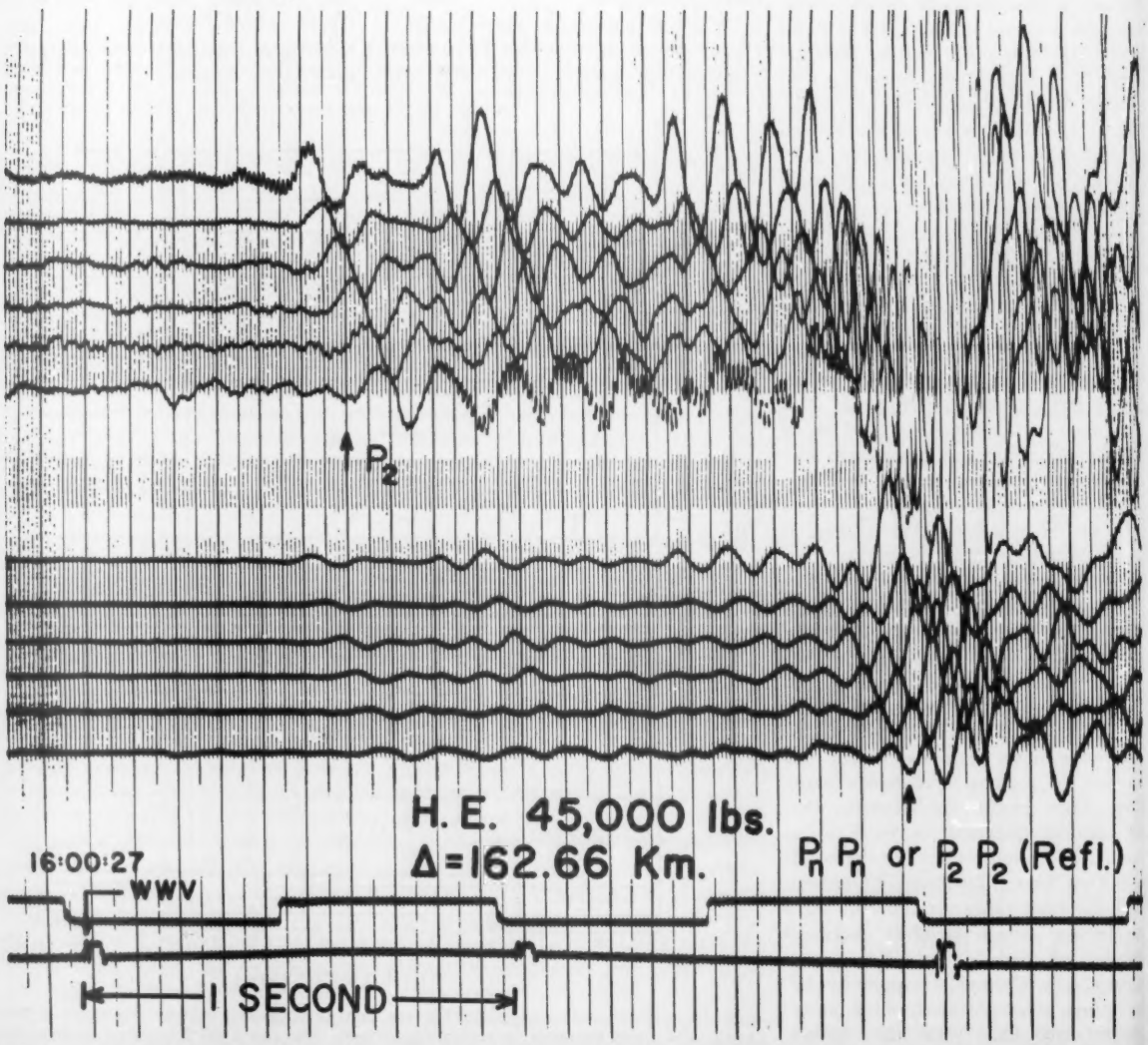
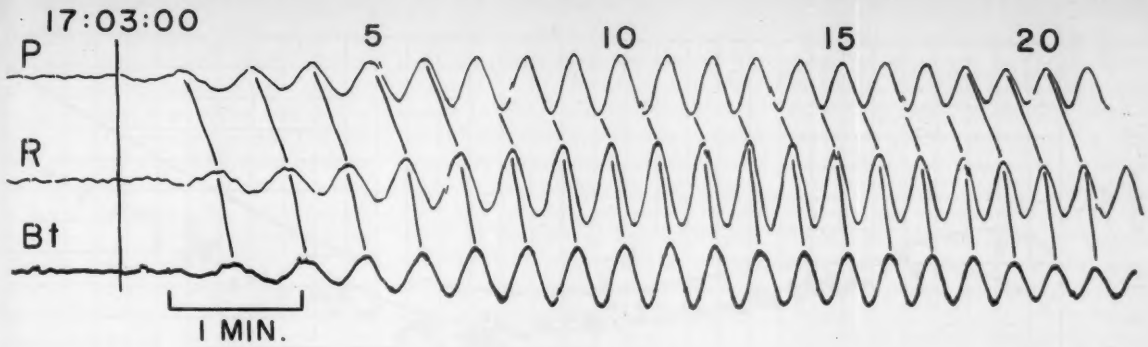
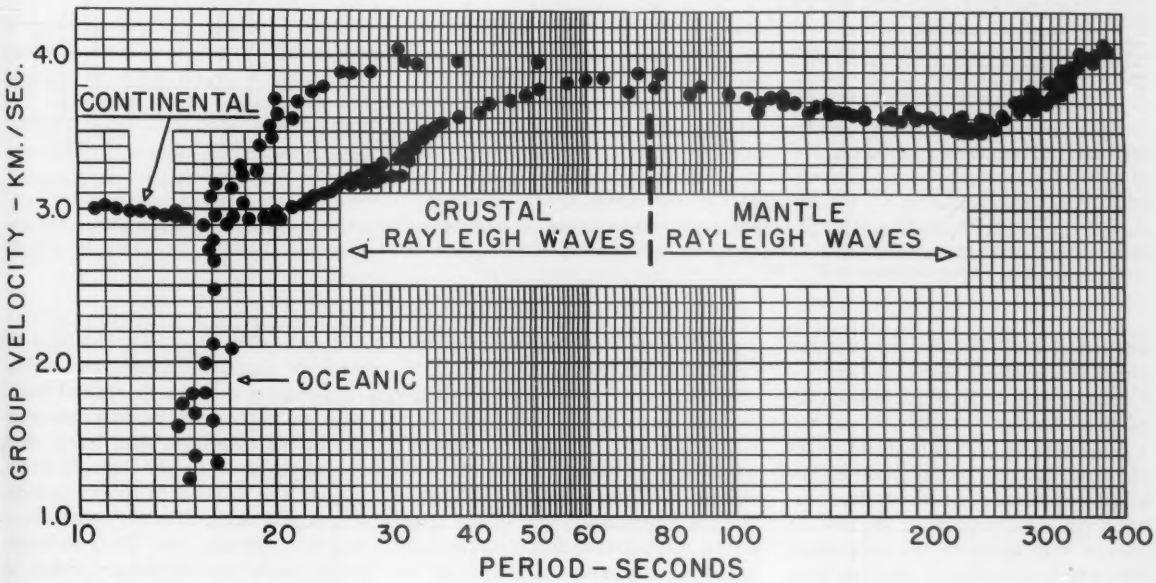


Fig. 5. Arrivals of refracted waves at a distance of 162 kilometers from the explosion. The lower six traces are a version of the upper six made with techniques of lower sensitivity. The detectors were separated by 1000 feet.





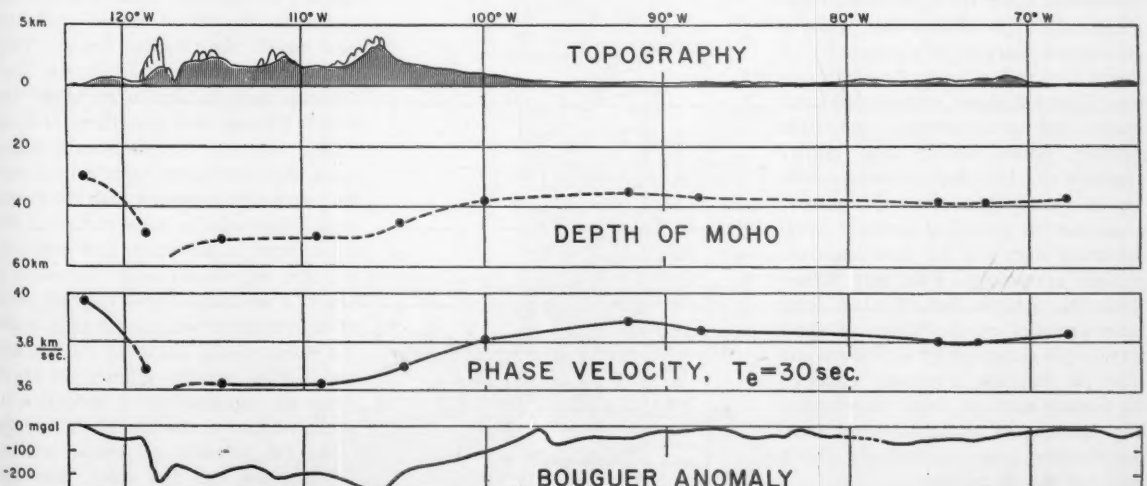


Fig. 6 (top). Rayleigh waves from an earthquake in the Solomon Islands, recorded by a triangular array of seismographs at Pasadena, Riverside, and Barrett, California, respectively. The seismograms are aligned with respect to time, and corresponding crests are indicated. Fig. 7 (middle). Observed dispersion of Rayleigh waves in the period range 10 to 400 seconds. [After Ewing and Press (7)] Fig. 8 (bottom). Profile across the United States, showing the relation of Rayleigh-wave phase velocity to topography and Bouguer anomaly. Depths to the Mohorovičić discontinuity are inferred from the phase velocity. [After Ewing and Press (9)]

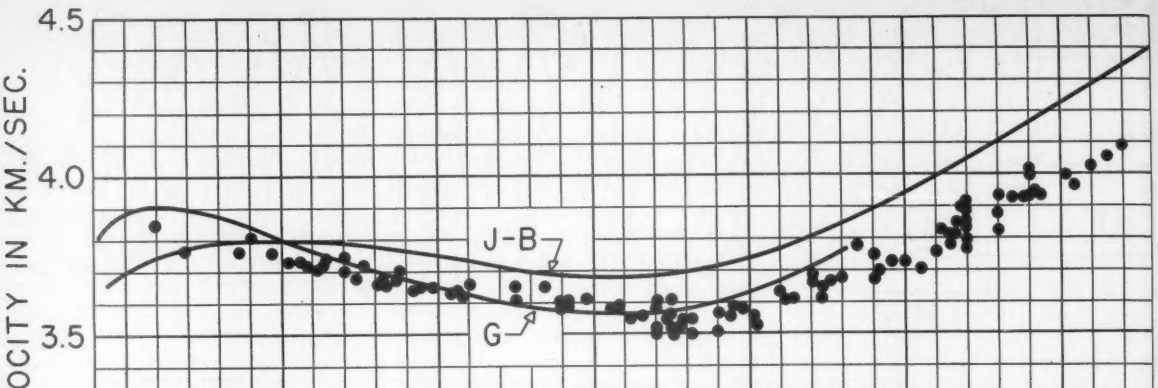


Fig. 9. Theoretical dispersion curves, showing that the curve based on the Gutenberg model of the mantle (which includes the low-velocity zone) fits the experimental data better than that based on the Jeffreys-Bullen model. The Jeffreys-Bullen model does not contain velocity inversion. [After Dorman *et al.* (*13*)]

that model which best fits the data and which is consistent with auxiliary information such as is available from refraction shooting.

A number of studies by these methods have recently been reported (*8*). In general, there is agreement that surface-wave data require an increase in velocity with depth in the continental crust which is consistent with the presence of the Conrad discontinuity. The continental crust thickens under topographically high regions and thins at continental margins in a manner consistent with regional isostatic compensation. Figure 8 shows a transcontinental profile with a remarkable correlation between phase velocity and gravity anomaly (*9*, *10*). Surface-wave results are in better agreement with gravity anomalies in revealing isostatic compensation than are the data from explosion seismology. This may follow from the greater influence of local heterogeneities on the waves of short wavelength generated by explosions and from the regional "averaging" effect of the surface waves of longer wavelength. The masking of refracted waves from intermediate layers is probably also a factor in this discrepancy.

The combined use of seismic refraction and surface-wave methods, together with gravity methods, offers a powerful tool with greater potential than any single method for arriving at a unique solution in regions of complicated structure (*11*).

Surface-wave results for the upper mantle are currently of great interest. Dispersion of mantle Rayleigh waves with periods from 100 to 400 seconds has been cited to demonstrate that the low-velocity zone of the upper mantle is a universal feature under continents and oceans, the minimum velocity occurring at a depth of about 140 kilometers (*12*). Figure 9, taken from the work of Dorman, Ewing, and Oliver (*12*), shows that the theoretical curve based on Gutenberg's model of the mantle fits the dispersion data better than the curve based on the Jeffreys-Bullen model. The Gutenberg model includes the low-velocity zone in the upper mantle, whereas the Jeffreys-Bullen model shows a continuous increase in velocity with depth. Dorman *et al.* (*13*) made the important discovery that the upper mantle differs under continents and under the Pacific Ocean. They favored the interpretation that the low-velocity zone is shallower under the Pacific Ocean. Aki and Press (*14*) reported that the Pacific mantle differs from the continental mantle in a way that would be consistent with the theory that a low-velocity zone occurs at the same depth under ocean and continent but that the velocity under the ocean is lower. They further presented evidence of differences between the mantle under the Pacific Ocean and under the Atlantic and Indian oceans—differences which could be explained by a reduction in shear velocity at the top of the mantle under the Atlantic and Indian oceans.

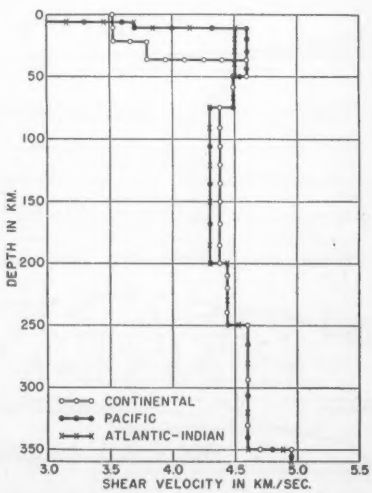


Fig. 10. Velocity-depth functions consistent with dispersion data for Pacific Ocean, Atlantic and Indian oceans, and continental paths. [After Aki and Press (*14*)]

Thus, for the first time, data are available which show that the mantle is not a symmetrical shell and that the oceanic and continental structures extend to depths of several hundred kilometers beneath the Mohorovičić dis-

continuity. Velocity-depth structure for the mantle under the Pacific Ocean, the Atlantic and Indian oceans, and the continents that is consistent with dispersion data is shown in Fig. 10. The layered structure is artificial, resulting from coding of the data for computation with a digital computer; the velocity-depth function is probably continuous. These are not unique solutions, but the differences between the curves represent real differences in the mantle of the type required by the data.

These results have important implications with respect to the genesis of continents and to continental drift. A complete physical explanation of the low-velocity zone has yet to be given. It is not unreasonable to expect that the velocity reversal is associated with a "softening" of rock due to the greater influence of temperature than of pressure at these depths. The low velocity could signify that the rocks at these depths are near the melting point. Verhoogen (*15*), among others, has pointed out that at depths between 100 and 200 kilometers the temperature comes close enough to that required for partial melting of basalt from a meteoritic material to make this a reasonable possibility. To speculate even further, the low-velocity zone may coincide, not only with the source of the primary basaltic magma, but also with the level of reduced strength, along which movements due to isostatic adjustment and polar wandering occur.

Gravity Observations

Bouguer gravity anomalies reveal an excess or deficiency of mass at depth, according to whether the sign of the anomaly is positive or negative. Since major density differences occur at the Conrad and Mohorovičić discontinuities, it is reasonable to expect that the anomaly may be explained in terms of variations in the depths of these interfaces, typically of the Mohorovičić. Geodesists have long recognized isostasy as a fundamental mechanism, from a study of gravity anomalies and their topographic association (*2*). Woollard (*16*) has recently reviewed the subject, making use of new seismic data. He finds that the relationship of Bouguer gravity anomaly with elevation (Fig. 11) and with crustal thickness (Fig. 12) is firmly established and reinforces the concept of isostatic compensation on a regional basis. A further conclusion can be reached from the form of the curve in Fig. 12—namely, that as the crust becomes thicker, its mean density increases. This is consistent with seismic observations that increased depth to the Mohorovičić discontinuity is usually associated with a thickening of the more dense, intermediate, basaltic layer rather than a thickening of the less dense, silicic top layer.

Isostatic compensation is regional

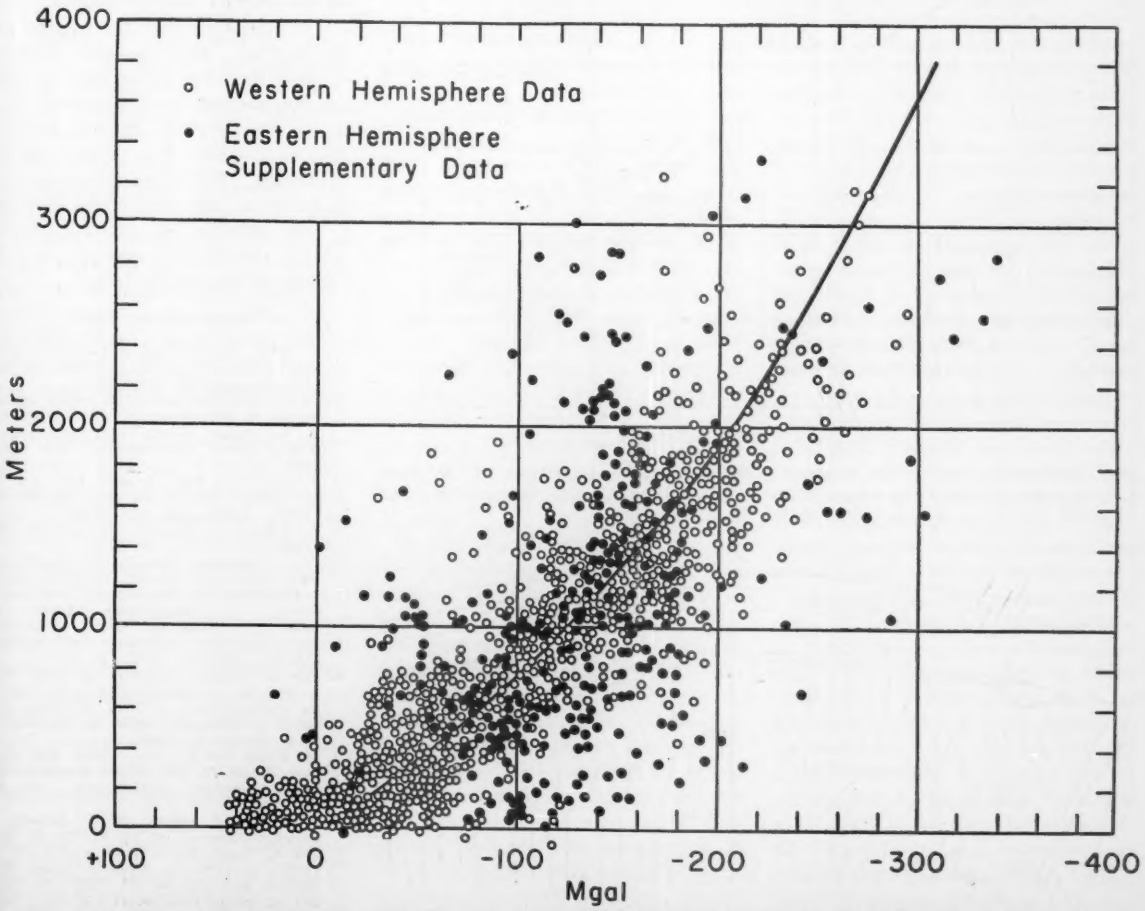


Fig. 11. Relation between the Bouguer gravity anomaly and topographic elevation. [After Woollard (*16*)]

rather than local. This can be demonstrated, for example, by noting that individual mountains in an uplifted region show little correlation between local topography and gravity (the main scarp of the Sierra Nevada Mountains is not evidenced in the gravity profile across this feature, for example).

It is noteworthy that the major release of tectonic energy in the form of earthquakes is associated with deep-sea trench-island arc structures in which the largest isostatic unbalance is known to occur. A recent result of great interest (*17*) demonstrates that a sharp downward flexure of the Mohorovičić discontinuity occurs at the seaward side of the trench. The stresses needed to maintain this texture in a state of isostatic unbalance are probably those also responsible for the seismic activity.

Remarks

A schematic summary of the status of our knowledge of the crust and upper mantle is shown in Fig. 13. The continental crust (*D*) shows a change in elastic parameters with depth in a way that would be consistent with the occurrence of light silicic rock (granite) at the top and more dense mafic rock (gabbro) at the bottom (*1*). In many places the contact is sharp and defines the Conrad discontinuity. The silicic layer shows less variability in velocity (*18*) than the mafic layer. The crust thins at the continental margin (*C*); it thickens under uplifts, mainly because of the increased thickness of the mafic layer (*E*). The oceanic crust (*B*) consists of rocks that correspond in density and elastic velocity with rocks found at the top of the continental mafic layer.

Island arcs and deep-sea trenches are associated with crustal thickening, the downward flexure in the Mohorovičić discontinuity occurring at the outer margin of the trench. The trench is isostatically uncompensated and tectonically very active, as evidenced by the high seismicity.

The velocity inversion in the upper mantle produces a minimum velocity at a depth of about 140 kilometers. The low-velocity zone of the upper mantle differs somewhat under continents and oceans, in a way that would be consistent with proposed higher temperatures (and "softer" rocks) under the oceans than under the continents. There is evidence which suggests that the top of the mantle has lower shear velocity (higher temperature?) under the Atlantic and Indian oceans than it has under the Pacific. The low-velocity zone is probably a result of temperature. Rocks near the melting point can occur in this zone, which may be the source of the primary basaltic magma.

The possibility that the Conrad and Mohorovičić discontinuities represent changes in phase rather than in composition has been much discussed. None of the measurements reported here enable us to take a firm position on this hypothesis. Plausible arguments can be made on both sides of the question; it will probably be resolved only by drilling through the oceanic crust to the top of the mantle. (*19*).

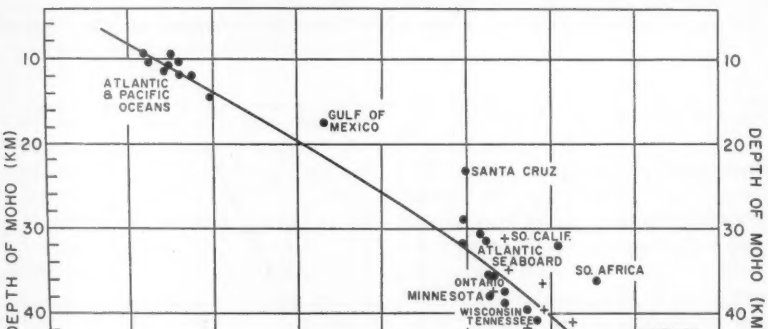


Fig. 12. Relation between the Bouguer gravity anomaly and thickness of the crust. Circles, points plotted from seismic refraction data; crosses, points plotted from data on phase velocity of surface waves. [After Woollard (*16*)]

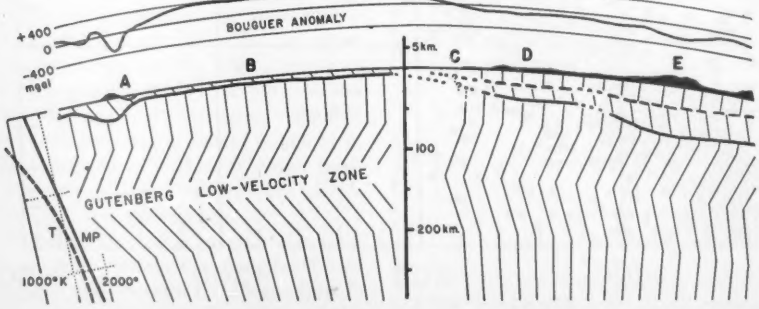


Fig. 13. Schematic diagram of the structure of crust and mantle. Solid curve (at left), melting point; dashed curve (at left), temperature.

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Patents and Inventive Effort

The evidence is insufficient to prove or disprove the claim that patent protection promotes inventive effort.

Fritz Machlup

A session of the December 1960 meeting of the AAAS was devoted to "The patent system and the advancement of knowledge." This issue, discussed for centuries, has never been resolved. Quotations from the U.S. Constitution, which empowered the Congress to establish patent and copyright laws "to promote the progress of science and the useful arts," cannot settle the question whether such laws actually serve this purpose. That patent protection may induce investment in further development and commercial application of new inventions is more readily conceded than that it is effective in inducing inventive activity where the corporate form of industry prevails. Doubts concerning this function of patents have been expressed with increasing frequency since the government contribution to research and development came to exceed half the total outlay. In 1959 private industry paid for less than 38 percent of total research and development in the United States. How important, then, can patent protection be in inducing inventive activity? Let us examine the arguments and sift the evidence that have been presented to answer this question.

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Large Corporations and Employed Inventors

Patent protection is supposed to serve as an incentive to invest in inventive work or to invest in development and plant construction or to disclose inventions that have been made. No matter which of these purposes are stressed, it is widely held nowadays that patents are not really important as incentives for large corporations, but only for independent inventors or for small firms competing with large ones. This view, strangely enough, is most emphatically stated by representatives of large corporations. Statements of this sort can be found in almost all Congressional hearings on patent legislation of the last 25 years.

If this contention is true, and we have no reason to doubt it, we are faced with the odd situation that patents as incentives for socially desirable activities are unnecessary for those who own the bulk of all patents. In the United States about 60 percent of all patents are assigned to corporations before issuance, which ordinarily indicates that the patented inventions were made by inventors employed by these corporations. Of all patents owned by corporations conducting research and development in 1953, 51 percent were owned by firms with more than 5000 employees, 30 percent by firms with between 1000 and 5000 employees, and only 19 percent by firms with less than 1000 employees. Thus it appears that those who hold most of the patents, the large corporations, testify that the patent system is not necessary for them, but only for those who hold the smallest number of patents.

In reply to the question whether patents are essential to the continuance of large expenditures for research and development, an officer of a large company stated that he might cut down these expenditures to perhaps one-half of the amount spent at that time if patent protection were removed. It happened, however, that approximately one-half of the research and development budget of that company was then devoted to the tasks of securing patents and enforcing the exclusive rights which they were supposed to confer. Hence, if the company were suddenly relieved of the necessity of spending money on obtaining patent rights and litigating about them, the remaining half of its budget would still buy the same amount of genuine research and development work. Most officers of large patent-holding corporations—except those in the chemical industry—do not think that their research expenditures depend on patent protection. For example, Robert E. Wilson, petroleum researcher and oil company executive, speculating about the possibly adverse consequences of a "weakening of the patent system," contended that this would *least* affect the research policies of *large* companies (*1*).

This judgment can be supported by deduction from the theory of oligopolistic competition: no firm in competition with a few others can afford to let its rivals steal a march upon it as far as the technological base of its competitive position is concerned. The research and development work is essential for the maintenance of its position. It cannot allow itself to fall seriously behind in the technological race, regardless of whether inventions promise it a 17-year patent protection, which in fact as a result of obsolescence means usually

Table 1. Number of domestic patent applications compared with population and number of technological workers, 1870–1950.

Year	Domestic patent applications (av. over 5 yr)*	Resident population (millions)†	Technological workers (millions)*	Patent applications per 100,000 population	Patent applications per 100 technological workers*
1870	18,600	39.91	1.51	46.60	1.24
1880	22,200	50.26	2.01	44.17	1.10
1890	35,800	63.06	3.13	56.77	1.15
1900	36,600	76.09	3.75	48.10	0.97
1910	59,400	92.41	5.39	64.29	1.10
1920	71,900	106.47	6.29	67.53	1.14
1930	73,700	123.08	7.10	59.88	1.04
1940	52,200	131.95	6.59	39.57	0.80
1950	60,100	151.23	8.59	39.74	0.70

*Source: J. Schmookler (*4*). The 1950 figures were supplied in an unpublished paper. †Source: *Historical Statistics of the United States.*

no more than a few years, or whether inventions promise it only a head start of two or three years or even only a means of catching up with the rivals. Hence it is not likely that the patent system makes much difference regarding the research and development expenditures of large firms.

Small Firms and Independent Inventors

Whether or not it is true that the patent system makes a serious difference regarding the competitive position of the small firm can hardly be decided on the basis of our present knowledge. There are strong arguments on both sides of the question. For example, the patent position of the big firms makes it almost impossible for new firms to enter the industry; patent litigation carried on by big firms makes it difficult for small firms to defend their own patents successfully. On the other hand, there are cases of small firms having succeeded, on the basis of strong patents on inventions of radically new processes or products, in gaining a position in markets previously dominated by a few giants. Be this as it may, this is a question of industrial organization, not a question of the effects of the patent system upon the production of new technological knowledge.

There still remains the problem of the individual inventor. The majority of writers have contended that the days of the free-lance inventor are gone, that invention has become the business of organized large-scale research and development in specialized departments of large corporations. John Jewkes is almost alone in denying this verdict, and he has adduced massive evidence to show that the individual inventors are still having a sizable share in the production of *important* inventions, even if their share in the production of commercially useful routine inventions has seriously declined. Jewkes believes that the individual inventor needs protection: "So long as the survival of the individual inventor is not utterly despaired of . . . and so long as nothing better can be suggested for the purpose, there is a very strong case for the retention of the patent system." (*2*).

Table 2. Number of scientists and engineers compared with number of patents issued, 1900–1954.

	(1)	(2)	(3)	(4)	(5)
Year	Scientists and engineers*	Index of growth of scientists and engineers	Patents granted for inventions†	Index of growth of patents granted for inventions	Index of relative growth of patenting in relation to scientists and engineers [col. (4) ÷ col. (2) × 100]
1900	42,000	100	24,660	100	100
1910	86,000	220	35,168	142	65
1920	135,000	320	37,164	150	47
1930	227,000	540	45,243	183	34
1940	310,000	740	42,333	171	23
1950	573,000	1,360	43,072	175	13
1954	691,000	1,640	33,872	137	8

*Source: National Science Foundation, *Scientific Research Personnel Resources* (1955), p. 9. †Source: *Historical Statistics of the United States, 1789–1945* (1949); *Statistical Abstract of the United States* (1955).

End of Growth in Patented Inventions?

In amazing contrast to the phenomenal growth in research and development expenditures and personnel since 1920, the number of inventions for which patents are sought has not increased since that time. The number of applications filed for patents on inventions was greater in 1920 than in any year during the 1950's, or indeed in any year since 1930. The number of patents actually issued happened to be relatively small in 1920, because applications had dropped during the years of World War I, and it is partly for this reason that the number of patents issued in the late 1950's exceeded that of 1920. The annual average of patents issued in the 10 years, 1950 to 1959, was 42,599, or only 2½ percent above the annual average of patents issued from 1920 to 1929, which was 41,492.

Examining the historical statistics of the patent system in the United States (*3*), we find that the peak in patent applications occurred in 1929, when 89,752 applications were filed. The largest number of applications filed in any year during the 1950's was 78,594, in 1959. The peak year for numbers of patents issued was 1932—note the customary 3-year lag behind applications—with 53,458 patents. During the 1950's the low was 30,432 patents in 1955, and the high was 52,408 in 1959.

The absence of growth, since 1920, in the absolute number of patents applied for or granted implies a decline in patenting relative to such magnitudes as population, the number of technological workers, of scientists and engineers, of professional research and development personnel, or the amounts of research and development expenditures. Some of these data are not available for all years; different tables, therefore, are used to show the relevant relationships. Table 1 compares the number of domestic patent applications with total population and with the number of technological workers in census years from 1870 to 1950. The number of technological workers, compiled by Jacob Schmookler, includes all occupations listed in the population census, whose members are skilled in a technical art or whose training includes some field of technology (*4*). Following Schmookler, we do not use the number of patent applications filed in just the census years—which would reflect the working capacity of the patent office rather than that of the inventors—but take 5-year

Table 3. Patent applications filed compared with the number of research and development (R&D) scientists and engineers and the amount of research and development expenditures.

Patent applications filed		Year	Research and development		Patent applications per 100 R&D scientists and engineers	Patent applications per $1 million R&D expenditures
Period	Av. per year*		Scientists and engineers† (thousands)	Expenditures‡ (in millions of $)		
(1)	(2)	(3)	(4)	(5)	(6)=(2)÷(4)	(7)=(2)÷(5)
1941–43	47,794	1941	87	900	54.94	53.10
1942–44	48,411	1942	90	1,070	53.79	45.24
1943–45	55,843	1943	97	1,210	51.57	46.15
1944–46	67,697	1944	111	1,380	60.99	49.06
1945–47	74,815	1945	119	1,520	62.87	49.22
1946–48	75,113	1946	122	1,780	61.57	42.20
1947–49	70,625	1947	125	2,260	56.50	31.25
1948–50	67,865	1948	133	2,610	51.03	26.00
1949–51	65,098	1949	144	2,610	45.21	24.94
1950–52	64,085	1950	151	2,870	42.44	22.33
1951–53	65,759	1951	158	3,360	41.62	19.57
1952–54	71,341	1952	180	3,750	39.63	19.02
1953–55	75,552	1953	192	4,000	39.35	18.89
1954–56	76,426	1954		4,140		18.46
1955–57	75,430	1955		5,400		13.97
1956–58	75,553	1956		6,500		11.62
1957–59	76,792	1957		8,200		9.36

*Source: *Historical Statistics of the United States*. †Source: National Science Foundation, *Scientific Research Personnel Resources* (1955), Table B-9. ‡Source: *Statistical Abstract of the United States* (1960).

averages centered on each census year, for example, the average of 1938–1942 for 1940.

We see from these data that between 1870 and 1920 patenting grew along with population and with the size of that group within the population which is likely to make inventions. The growth of patenting apparently stopped after the 1920's, and patent applications relative to population and to the number of technological workers declined rapidly.

Table 2 reproduces a table prepared by Seymour Melman to show the contrast between the growth of the number of scientists and engineers and that of patents issued, for the period 1900 to 1954. Table 3 is confined to a more recent period, beginning in 1941, for which research and development data, however unreliable, are available; it compares the number of research and development scientists and engineers and the amounts of research and development expenditures with the average annual number of patent applications filed during consecutive 3-year periods.

Why the Relative Decline?

These comparisons show a conspicuous decline in patenting relative to the presumably relevant variables. This decline has aroused a big debate: does the decline in patenting indicate a similar decline in the relative number of inventions? or only in the relative number of patentable inventions? or perhaps merely a decline in the "propensity to patent"? Of course, these are not disjunctive alternatives; all three things may have happened, and there are good reasons for believing that this is actually the case.

Easiest to explain is the decline in the number of patent applications per million dollars spent on research and development. We have only to remember the enormous portion of research and development funds that goes into aircraft development (missiles, rockets, space ships, and so forth) and that it is most unlikely that patentable inventions will grow out of the extensive and expensive experimentation in this area. No matter whether the solutions of the many technical problems which we try to get in a hurry are regarded as inventions, combinations of inventions, improvements, or anything else, they are not likely to meet the requirements of patentability. The same explanation would hold for the decline in patent applications per 1000 research and development scientists and engineers. Like the research and development expenditures, the professional research and development staff has been similarly concentrated in the aircraft industry, in attempts to find out as quickly as possible what combination of fuels, metals, devices, and all the rest, would make certain types of missiles, and so forth, operational. The implications of the comparisons in question have not always been fairly presented. While it is fair to conclude that patents play a relatively small role in the present research and development activity, in the sense that they are neither a necessary incentive for, nor a likely result of, the research and development effort, it would not be fair to conclude from the data that patents no longer play a role in any part of the nation's inventive effort.

Patents and Research Expenditures

The chemical industry suggests itself as an example of an industry in which patents may play a role. While it usually ranks behind three or four other industries as far as total research and development expenditures are concerned, it rises to rank No. 1 if the industry's own contributions of funds for research and development are compared. At the same time the chemical industry holds rank No. 1 in the number of patents pending. This "rank correlation" between patent applications and self-financed research and development expenditures does of course not prove anything, but at least it conforms to the traditional theory of the patent incentive. Incidentally, if for all industries the government funds are disregarded and only the industry's own funds for research and development are taken into account, the rank correlation between these research and development expenditures and the number of patent applications pending is very high. The data for this statistical test were taken from the National Science Foundation's 1953–54 survey, *Science and Engineering in American Industry*.

A high correlation between self-financed research and development expenditures and applications for patents strongly suggests that industry tends to spend its own money on inventive efforts where these efforts are most likely to lead to inventions. It does not establish that these expenditures would not be made without the promise of patent protection. Undoubtedly, if there is a chance to obtain patents on inventions, industry will not pass up this chance. But it cannot be demonstrated from any statistical relationships that only the patents rather than the inventions were wanted, or that inven-

tions without patents would not have been considered worth the money spent on research. As was said earlier in this article, to have a headstart on new processes or products, even if competitors are not barred from imitation, or to catch up with competitors who are leading in the race for new technology, may be sufficiently desirable in a world of oligopolistic competition to bring forth all the inventive efforts that are now attributed to the patent incentive.

The absence of any empirical evidence for either the claim or its denial that the patent system is an effective promoter of inventive research—and thus of the production of socially new technological knowledge—is most frustrating. The doubting Thomases are usually timid and reserved lest they invite the wrath of the faithful. [A recent denial of the claim, by Seymour Melman, is quite exceptional in its directness (*5*).] Advocates of patent protection have for centuries propounded the faith in this institution, and their statements admit of not an iota of doubt. They may well have the truth—but faith alone, not evidence, supports it.

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Science in the News

Kennedy's Education Program: Notes on the Political Background

The Administration's education program is beginning to emerge from the House and Senate committees, and it appears that the bills which reach the floor of each house will be in substantially the form Kennedy has requested: grants, in the neighborhood of $1 billion a year, to the states for public schools; loans on about the same scale for universities, both public and private; and an expansion of the federal loan program for students. Kennedy also requested a scholarship program, which may not appear in the committee versions, although, if outright scholarships are not included, an alternative limiting the amount of money students entering low-paying professions will have to repay to the government is likely to be included in the loan program.

The different parts of the program vary widely in their prospects. Expansion of the established loan programs for colleges and college students can be taken for granted. The outlook for a scholarship program or the alternative of generous forgiveness provisions in the loan program is less clear. The proposals have never been fully discussed before in Congress, and few members outside the committees concerned with education have committed themselves to any particular approach. Aid to public schools, including teachers' salaries as well as construction, is another matter: it has been widely debated for years, and remains by far the most controversial item.

The handling of the education program, particularly the issue of teachers' salaries, is likely to prove the most severe test to date of the Administration's relations with Congress. Kennedy has yet to be beaten on an important issue, but he also has yet to commit himself on an issue on which the outlook, based on votes last year and on the known positions of new members, looked so dismal.

On this basis, the nonpartisan Congressional Quarterly estimated at the beginning of the session that any school bill, even one excluding teachers' salaries, faced an apparent deficit of 27 votes in the House of Representatives. By this standard, the outlook for a school bill including money for teachers' salaries would be virtually hopeless, although since the teachers' salary issue has never reached a vote in the House it is hard to estimate the apparent vote deficit. But Congressional Quarterly attempted only to measure what can be fairly precisely measured: the known inclinations of the members of the House. The difference between certain defeat and at least a fair chance for victory is the power of the Presidency, which Kennedy has never yet fully used.

The Kennedy forces pushed through the minimum wage bill last week by a margin of 35 votes in the House, although in the form Kennedy proposed the bill faced, by Congressional Quarterly's estimate, an apparent deficit of 54 votes. The margin of victory, though generally regarded as surprisingly large, was far from comfortable: the margin was wide only when compared with the five-vote margin by which the Kennedy forces won the Rules Committee dispute. The vote was 231 to 196, and a shift of 18 members out of the 427 who voted would have defeated the bill.

Political Tactics

The factors that made a fairly narrow Administration victory possible on minimum wages would not be enough to push across a school bill with money for teachers' salaries, but they will provide a basis for the effort the Administration needs to make to have a chance. Both bills are handled by the same House committee, Education and Labor. Last year the chairman of the committee was Graham Barden, of North Carolina, one of the most conservative of the Southerners. Barden retired last year, and Adam Clayton Powell, of Harlem, succeeded by the usual seniority rule. The chairman has great powers to delay, if not to kill, legislation he disapproves. Powell has a good claim to being the most unpopular man in the House, but

he is a liberal, and whatever his fellow liberals may think of him personally, his replacement of Barden as chairman of the committee eliminated one of the obstacles for the Administration's program.

A second obstacle was eliminated with the change in the Rules Committee, to which new members were added to give the Administration a majority. Last year the liberals had to fight to get their bills through Barden's committee, and then fight again to get them through the Rules Committee. This year the path is clear. The minimum wage bill, for example, was cleared by the Rules Committee last year only after the committee had assurance that the House conference representatives would refuse to accept any compromise with the more liberal Senate version of the bill. The House substituted a limited wage bill for the bill that had come out of committee by almost the same vote as it did this year. The House conferees, led by Barden, refused to make any concessions to the Senate conferees, led by Kennedy, and the conference collapsed. This year, the House conferees, now led by Powell, quickly agreed to a bill very close to what the Senate (and the Administration) had proposed. When the conference report came before the House, a number of members who did not mind voting *for* a substitute minimum wage bill did not care to vote *against* the only minimum wage bill before them, and the Administration won its victory.

Conference Report

This may indeed set the pattern for the school aid bill, with the Administration losing in the House at first, when the members are able to vote on teachers' salaries as a distinct issue, and winning when the House is faced with a conference report including teachers' salaries, and the members have to vote for or against aid to education in general. On education, as on its program in general, the Administration has virtually no worries about the Senate, where a liberal coalition that includes about a third of the Republicans plus most of the Democrats has been regularly giving the President margins of about 2 to 1.

But the strategy of hoping for a victory on the conference report to reverse a preliminary defeat in the House will normally work only if the vote in the House has been fairly close. This was the case with the minimum wage bill: the House adopted a substitute for the Administration bill by only a dozen votes out of more than 420. The Senate supported the Administration by about 2 to 1. Given the close division in the House and the wide margin in the Senate, it was natural that the compromise version would be closer to the Senate's version. If the earlier vote in the House had been less close, the liberals would still have controlled the conference and could have given in just as much to the Senate; but in addition to having to change more votes to get the conference report approved they would have had to counter the resentment of House members who, while privately favoring the Senate version, felt the terms of compromise were degrading to the House. Nevertheless, the nature of Congressional procedure, combined with the liberals' control of the Rules and Conference committees, gives the liberals important tactical advantages they lacked last year.

Power of the Presidency

The most important factor, though, is the power of Presidency. Control of procedural machinery is an asset to the liberals, but the main value of this newly won control is not so much in what the liberals can do with it as in what the conservatives can no longer do with it. The great power of procedural devices lies in their usefulness to obstruct, a power the liberals, who are normally working for the passage of legislation, have little occasion to use. (This is what gives rise to the legends of the wily conservatives frustrating the liberals through their superior understanding of the niceties of parliamentary procedure. The liberals are not less wily; they merely have less occasion to use procedural devices, whose principal value is to keep things from being done.)

The force of the Presidency, too, can be important in a negative way, for there is no greater procedural obstruction than the presidential veto requiring a two-thirds majority in each house for a bill to become law over the president's opposition. Senator Dirksen, the minority leader, was a member of the Senate-House conference committee that produced the final minimum wage bill. In the closing moments of the debate on the conference report he turned to Pat McNamara, of Michigan, chairman of the Senate conferees. "I shall take no further time," said Dirksen, "except to say to my congenial chairman: perhaps I ought to congratulate you for getting [the liberal version of] the bill before us this year. I did my best to stop it before, as the Senator knows. I did not succeed. I always had one hope before, because, having made the best fight of which I was capable, I could then say, 'Well, if we can only get one third plus one, maybe we are still safe.' I cannot say it any more. . . ."

Here again, the liberals' control of procedure, at the White House as well as on the Congressional level, is valuable in the negative sense of keeping procedural obstruction from coming into play. But here, more than in the House, formal control carries with it a great deal of power, which Kennedy, despite a good deal of talk about his vigorous handling of the office, has never yet tried to exert to the full.

As a number of observers have been pointing out lately, Kennedy has yet to use his position to make a direct appeal to the public for support on specific issues, explaining just what he wants Congress to do and why he thinks the country should be behind him. Two things limit the use of this power: the President cannot use it too often without both dissipating its impact and provoking Congressional resentment, and he must be wary of using it on an issue where he is likely to lose, despite its use, for this, too, would lessen its effectiveness the next time it is needed.

On minimum wages, Kennedy did not choose to make such a fight. He accepted the exclusion from the bill of several hundred thousand workers who most need coverage. None of the Administration's supporters attempted to defend this on any ground save that of expediency. The President got the main thing he wanted: broad expansion of the concept used to define what businesses fall under the Constitution's interstate commerce clause, which provides the authority for minimum wage legislation. He then accepted exemption of some important groups in order to get the votes needed to push the bill across, presumably with the intention of trying to get the exemptions repealed next year.

The question on school aid is whether he is willing to settle for the principle of federal aid this year, and hope to expand it in the future, or whether he will fight for large-scale aid this year by making a strong appeal for public support, with the pressure this will bring on reluctant Congressmen to go along with the Administration.

Notes

Mental Health in the House Rules Committee

The now well-known House Rules Committee performs two related but distant functions; one, which was the subject of the controversy at the opening of Congress, is that it writes a "rule" specifying the terms of debate for bills reported by other committees. A bill normally cannot be debated until the Rules Committee has reported a rule specifying such things as length of time for the debate and whether amendments will be allowed. This gives the committee the power to delay a bill indefinitely by simply never getting around to writing a rule. The "reform" or "packing" of the committee in January gave the Administration a majority on the committee, and thus assurance that its program would not die there waiting for a rule.

The committee also acts as committee of first jurisdiction on proposals to change the rules of the House or to set up special investigating committees.

Acting in this second role, the Rules Committee this week considered a resolution by Representative Hiestand, of California, a member of the John Birch Society, to set up a special committee to investigate mental health. If such a resolution were approved, Representative Hiestand, as its sponsor, would normally be made chairman of the special committee.

Representative Hiestand said that in the early 1930's Lavrenti Beria, the executed former chief of Soviet secret police, had told a group of American communists that the way to take over America was to push mental health, and use this as a pretext for locking anticommunists up in the insane asylums. Representative Hiestand noted that there is a great campaign in favor of mental health going on now; that, in his view, "commitment processes are very loose;" and that "a man can be picked up on the flimsiest sort of evidence and he'll never get out if they want to keep him in."

The purpose of his investigation, said Hiestand, is to find out "how much of this is controlled by the far-reaching fingers of the Communist conspiracy. . . . We have a lot of evidence."

Judge Smith, who lost most of his power in January but remains chairman of the committee, set the tone of the committee's reaction, by telling about his college days, a great many years ago, when he had a professor who had a mentally defective son. One day, said the Judge, the professor decided he had to have the boy committed, and took him off to an asylum. But when they got to the asylum, the Judge said, "the boy spoke up first, and, well, that old gentleman had an awful tough time getting out of there."

Soon after, with everyone but Representative Hiestand in high spirits, the committee adjourned.

Announcements

Academy Elects New Officers and Members

During the 98th annual meeting of the National Academy of Sciences, held 25 April, in Washington, **J. A. Stratton**, president of Massachusetts Institute of Technology, Cambridge, was elected to a 4-year term as vice president of the Academy. Also elected, to serve 3-year terms as members of the Council of the Academy, were **George B. Kistiakowsky**, professor of chemistry at Harvard, and **Kenneth B. Raper**, Abbott and James Lawrence professor of bacteriology and botany at the University of Wisconsin.

In addition, 35 new members were elected during the meeting, as follows:

Daniel I. Arnon, professor of plant physiology, University of California.

William O. Baker, vice president in charge of research, Bell Telephone Laboratories.

Seymour Benzer, professor of biophysics, Purdue University.

Harry A. Borthwick, principal plant physiologist, Agricultural Research Service, U.S. Department of Agriculture.

Robert H. Burris, professor of biochemistry, University of Wisconsin.

Shiing-Shen Chern, professor of mathematics, University of California.

Preston E. Cloud, Jr., chief, paleontology and stratigraphy branch, U.S. Geological Survey.

Julius H. Comroe, Jr., director of Cardiovascular Research Institute and professor of physiology, University of California Medical Center.

Donald J. Cram, professor of chemistry, University of California.

James F. Crow, professor of zoology and genetics, University of Wisconsin.

Lawrence S. Darken, associate director, research laboratory, United States Steel Corporation.

Carl Djerassi, professor of chemistry, Stanford University.

William V. E. Doering, professor of chemistry, Yale University.

Renato Dulbecco, professor of biology, California Institute of Technology.

Alfred I. Hallowell, professor of anthropology, University of Pennsylvania.

Bernard L. Horecker, professor of microbiology, New York University College of Medicine.

Rollin D. Hotchkiss, member and professor of cellular physiology, Rockefeller Institute.

Libbie H. Hyman, research associate, American Museum of Natural History.

Mark G. Inghram, professor of physics, University of Chicago.

William N. Lipscomb, Jr., professor of chemistry, Harvard University.

Herman F. Mark, director, Polymer Research Institute, Polytechnic Institute of Brooklyn.

Hans Neurath, professor of biochemistry, University of Washington.

George E. Palade, member and professor of cytology, Rockefeller Institute.

Robert V. Pound, professor of physics, Harvard University.

Lorrin A. Riggs, professor of physiological psychology, Brown University.

Richard B. Roberts, Department of Terrestrial Magnetism, Carnegie Institution of Washington.

Per F. Scholander, professor of physiology, Scripps Institution of Oceanography.

Charles D. Shane, astronomer, Lick Observatory.

Donald C. Spencer, professor of mathematics, Princeton University.

Henry M. Stommel, research associate in physical oceanography, Woods Hole Oceanographic Institution.

Leo Szilard, professor of biophysics, University of Chicago.

John W. Tukey, professor of mathematics, Princeton University.

Frederick T. Wall, research professor of physical chemistry, University of Illinois.

Alvin M. Weinberg, director, Oak Ridge National Laboratory; and

John H. Williams, professor of physics, University of Minnesota.

A report on **science in Communist China** has been released by the National Science Foundation. In *Professional Manpower and Education in Communist China*, Leo A. Orleans,

senior research analyst at the Library of Congress, reports that the number of individuals capable of advanced scientific research in China is small, and that major emphasis is placed on immediate application. According to Orleans, the Chinese scientist does not conduct high-level research but finds it expedient at this stage in his country's development "to borrow existing knowledge from the more advanced nations and convert it to the special needs and present level of Chinese technology." (Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. $2.)

The Colonial Microbiological Research Institute, Port-of-Spain, Trinidad, established in 1948 by Lord Hankey, then chairman of the Colonial Products Research Council, was officially closed on 30 April. The institute had been financed from Colonial Development Research funds until April 1960, and by the Government of Trinidad and Tobago during the past year. Scientific consultants and West Indian officials decided that other forms of research should receive higher priority.

Meeting Notes

Antimicrobial agents and chemotherapy. The American Society for Microbiology, formerly the Society of American Bacteriologists, will hold a series of annual meetings, to be known as the Interscience Conference on Antimicrobial Agents and Chemotherapy. The first meeting will be held in New York from 31 October to 2 November.

Microbiologists, chemists, biochemists, pharmacologists, pathologists, clinicians, and members of related disciplines who are interested in the role of antimicrobial agents in infectious diseases and in viral and cancer chemotherapy are invited to present papers. These should emphasize the interdisciplinary relationships or specific aspects of research in chemotherapy and in the nature and action of antimicrobial agents, natural and synthetic. Among the areas of interest are new antibiotics and methods for obtaining them; fermentation; taxonomy; isolation, purification, identification, and synthesis of antimicrobial agents; methodology in experimental chemotherapy; and clinical aspects, including the development of resistance and allergy. (American Society for Microbiology, 19875 Mack Ave., Detroit 36, Mich.)

Climate. The UNESCO–WMO symposium on changes of climate with special reference to the arid zones is to be held from 2 to 7 October in Rome. During the opening session, Luna Leopold (U.S. Geological Survey) will speak on the problem of changes of climate, especially in arid and semiarid regions. The working sessions will be held at Food and Agriculture Organization headquarters. Chairmen for the four sections of the symposium are as follows:

Changes during the period of meteorological records: R. C. Veryard, Meteorological Office, Air Ministry, Harrow, England.

Changes during the late geological and early historical record: K. W. Butzer, University of Wisconsin, Madison.

Theories of changes of climate: R. C. Sutcliffe, president of WMO's Commission for Aerology.

Significance of changes of climate: R. O. Whyte, Plant Production and Protection Division, FAO.

The closing session will be devoted to a synthesis of the results of the symposium, based on a review by C. C. Wallen, deputy director, Swedish Meteorological and Hydrological Institute, Stockholm.

New Journals

Journal of Atherosclerosis Research, vol. 1, No. 1, Jan.-Feb. 1961. E. Aaes-Jørgensen, Ed. Elsevier Publishing Company, 110–112 Spuistraat, Amsterdam, Netherlands. Bimonthly. $17.50 per year.

American Zoologist, vol. 1, No. 1, Feb. 1961. S. Crowell, Managing Ed. American Society of Zoologists, 104 Liberty St., Utica, N.Y. Quarterly. $9 per year.

Review, vol. 1, No. 1, Mar. 1961. B. Pešić, Ed., "Borba," Trg Marksa i Engelsa 7, Belgrade, Yugoslavia. Monthly.

International Chemical Engineering, vol. 1, No. 1, Oct. 1961. W. Hoffman, Ed. American Institute of Chemical Engineers, 25 W. 45th St., New York 36, N.Y. Quarterly.

Journal of Theoretical Biology, vol. 1, No. 1, Jan. 1961. J. F. Danielli, Ed. Academic Press, 111 5th Ave., New York 3, N.Y. $17 per volume.

Scientists in the News

Ritchie Calder, British science writer, has won the 1960 Kalinga prize for the popularization of science. The prize of £1000, offered for the past 9 years by the Kalinga Foundation of the Indian state of Orissa, is awarded annually by an international jury appointed by UNESCO. It was established "to offer recognition to leading interpreters of science and . . . to strengthen links between India and scientists of all nations."

George W. Beadle, winner of the 1958 Nobel prize in physiology and medicine, has been installed as chancellor of the University of Chicago. Beadle, who was formerly chairman of the division of biology at California Institute of Technology, shared the prize with Edward L. Tatum and Joshua Lederberg for work on the chemistry of genes. He becomes the seventh chief executive of the university and the third to bear the title of chancellor. He succeeds Lawrence A. Kimpton, who retired last year.

Gioacchino Failla, professor emeritus of radiology, Columbia University, and senior physicist emeritus of Argonne National Laboratory's Radiological Physics Division, has been awarded the annual medal of the James Ewing Society for work in radiological physics as applied to the radiation treatment of cancer. Failla, who has been a consultant to the laboratory since 1946, joined the staff of the Radiological Physics Division in 1960.

John A. Knauss, assistant research oceanographer at the University of California's Scripps Institution of Oceanography, has been appointed dean of the new graduate school of oceanography and professor of oceanography at the University of Rhode Island. In 1962 he will head a joint expedition of the University of Rhode Island and the University of California to study equatorial circulation in the Indian Ocean.

A U.S. Atomic Energy Commission citation has been presented to **Warren C. Johnson**, University of Chicago scientist and administrator, in recognition of his service in advancing the atomic energy programs of the Commission and of the United States. The citation was established in 1960 in order to

honor individuals who had served the Commission but were not employed by it.

Seymour Benzer, professor of biophysics at Purdue University, has been named recipient for 1961 of the University of Chicago's Howard Taylor Ricketts memorial award. Ricketts, a University of Chicago bacteriologist, discovered that ticks transmit Rocky Mountain fever.

J. Edward Donnellan, Jr., of the department of radiology at the Yale University School of Medicine, has been appointed physicist (biophysics) in the Bacteriology Laboratory, Pioneering Research Division, U.S. Army Quartermaster Research and Engineering Center, Natick, Mass.

Ashley A. Miles, director of the Lister Institute of Preventive Medicine, London, is giving the first annual Milton J. Rosenau Lecture at Harvard University's School of Public Health. The new lectureship was established in honor of Dr. Rosenau, who founded at Harvard the first department of preventive medicine in a medical school in the United States.

Jirair H. Arsenian, senior medical officer to the United Nations Relief and Works Agency in Jordan, has been named the first recipient of a fellowship provided by the Arabian American Oil Company for 1 year of graduate study at the Harvard School of Public Health. The fellowship was established in the interest of improving health conditions in Saudi Arabia and the Middle East.

William T. Caldwell, dean of Temple University's College of Liberal Arts since 1942, has resigned to assume the post of research professor of chemistry in the university. Caldwell was appointed an instructor in chemistry at Temple in 1919 and became head of the chemistry department in 1926.

I. I. Rabi, of Columbia University, has been elected president of Associated Universities, Inc., a consortium of nine major northeastern universities that operates Brookhaven National Laboratory, Upton, N.Y., and the National Radio Astronomy Observatory, Green Bank, W. Va., for the government. He succeeds **Leland J. Hayworth**, who resigned to become a member of the Atomic Energy Commission.

S. D. Larks, assistant professor in the biophysics department, University of California (Los Angeles), has been appointed professor of electrical engineering at Marquette University. He will organize a new program of teaching and research in bioelectric phenomena and biomedical engineering.

Elmer V. McCollum, professor emeritus of biochemistry at Johns Hopkins, has been elected a foreign member of the Royal Society, London.

Gardiner L. Tucker, manager of the San Jose (Calif.) Research Laboratory of the International Business Machines Corporation, has been named director of development engineering at the I.B.M. World Trade Corporation in New York, succeeding **Ralph G. Mork**, who has been appointed manager of the Engineering Laboratory, I.B.M. Federal Systems Division Command Control Center, Kingston, N.Y.

Donald S. Fredrickson has been appointed clinical director of the National Heart Institute's Intramural Research Program. He has been serving as a senior staff member of the section of metabolism in the Heart Institute Laboratory of Cellular Physiology and Metabolism.

Harold F. Schuknecht has been appointed the sixth Walter A. Lecompte professor of otology and professor of laryngology at Harvard University and chief of otolaryngology at the Massachusetts Eye and Ear Infirmary, effective 1 July. Since 1953, Schuknecht has served as associate surgeon and director of the Otological Research Laboratory at the Henry Ford Hospital in Detroit. He is internationally known for the "Schuknecht operation" to alleviate deafness.

J. C. Dickinson, Jr., acting director of the Florida State Museum of the University of Florida, has been named director. He succeeds **Arnold B. Grobman**, who will continue as director of the AIBS Curriculum Study in Biological Sciences at the University of Colorado in Boulder.

Friedrich W. Hoffmann, chief of the agents research branch of the U.S. Army Research and Development Laboratories, Army Chemical Center, Md., has accepted an appointment as associate professor of chemistry at the University of Delaware. However, he will continue to fill his research post at the Army Chemical Center, where he has been associated with the Chemical Corps since 1947.

David A. Hamburg will become professor and executive head of the department of psychiatry of the Stanford University School of Medicine on 1 August. Hamburg is now chief of the Adult Psychiatry Branch of the National Institute of Mental Health in Bethesda, Md. He is an authority on the effects of psychological stress upon human behavior, particularly among high school and college students.

Karl Maramorosch, for 12 years a member of the Rockefeller Institute staff, has been appointed senior entomologist at the Boyce Thompson Institute for Plant Research, Inc., Yonkers, N.Y. In 1960, at the request of the Food and Agriculture Organization of the United Nations, Maramorosch took a 6-month leave to serve as virologist and adviser to the Philippine Government on the cadang-cadang disease of coconuts.

Frank Morrell, who is widely known for his studies of epilepsy and for basic research on the molecular basis of learning, has been appointed professor of medicine and head of the division of neurology at Stanford University School of Medicine. He succeeds the late Henry Wise Newman as division head. Morrell is former associate professor of neurology and neurophysiology at the University of Minnesota. In addition to holding the faculty post at Stanford, he is executive of the division of neurology for Palo Alto-Stanford Hospital Center.

Wade H. Marshall, chief of the Laboratory of Neurophysiology, National Institute of Mental Health–National Institute of Neurological Diseases and Blindness, has recently been made a foreign member of the Brazilian Academy of Science.

Gerson Kegeles, professor of chemistry at Clark University, has been named to succeed **Arthur E. Martell** as chairman of the university's chemistry department. Martell, a member of the Clark faculty since 1942 and department chairman since 1959, resigned last fall to become chairman of the department of chemistry at Illinois Institute of Technology. He assumed his new post in February.

Book Reviews

Social Change in Latin America Today. Richard Adams, John P. Gillin, Allan R. Homberg, Oscar Lewis, Richard W. Patch, and Charles Wagley. Published for the Council on Foreign Relations by Harper, New York, 1961. 353 pp. $5.

This book, by six of our best anthropologists, is addressed to all who have a hand in our foreign affairs; perhaps that means all of us. The particular subject—Latin America and why it gives trouble to its well-meaning neighbor to the North—needs attention; so does the more general answer.

Anthropologists are trained to the reverse view—how does what *we* are, and what *we* do, look to "them"? The facts may not be very helpful; if the only way that *A* can behave to *B* is perceived by the first as altruistic and by the second as exploitative, disillusioning *A* may help neither *A* nor *B*, but is it not better to know these facts? In any case anthropologists prefer, pursue, and try to expound reality, whether or not it leads to useful application.

This book includes excellent analyses of what goes on in Peru (Allan R. Holmberg), Bolivia (Richard W. Patch), Brazil (Charles Wagley), Guatemala (Richard N. Adams), and Mexico (Oscar Lewis, whose chapter shows the remarkable progress "Since Cárdenas"). Every case is different but all share a strong urge for a better life, perhaps meaning—and this is important—North American things without North American values. The sleep of the long colonial era is shaken from the eyes at least of the middle class just emerging. If history is written later, it will say that, for these countries, the 19th century saw political independence without social change, the 20th a social and economic revolution, beginning in Mexico in the 1930's. Those who had and held and kept their share from the populace were overturned; and their colleagues to the North became the proper scapegoat for unresolved problems and a means to unite the heterogeneous nation. They wound up as socialist republics, not because of ideological predisposition but because central state control was the old tradition. In the light of this long-term perspective, what do the anthropologists suggest for 1961?

John P. Gillin's introductory article, "Some signposts for policy," says most here. Gillin, with long experience in all sections of the continent, in both research and government, is father of a conception of a "middle" Latin American culture; and now he describes the "middle mass." Some of his recommendations are politically neutral—better coordination of U.S. government agencies and of the efforts of private business and public agencies operating in Latin America; establishment of a research center here; and the like. Others tell us to take sides in the social struggle, to establish personal relations with the leaders of the "middle group" and to support the new leadership against dictators. Still others seem neutral; they suggest that in our programs to help Latin Americans modernize we should honor their own intelligence, traditions, and the like, but imply that we must help Latin American nations establish programs which we think of as "socialist."

Nothing in the particular studies contradicts these conclusions, though Patch and Holmberg suggest that the critical factor in Bolivia (which has had a social revolution) and Peru (which has not) is small-scale community development of Indian villages, while Wagley for Brazil stresses large-scale town and city solutions.

For all its richness of data, ideas, and understanding, the book has a major weakness. The authors held six discussion meetings led by the late Lyman Bryson, who wrote an introduction; yet nowhere is there an attempt at synthesis or comparison. It would be particularly interesting to understand the relative, and striking, success of Mexico, which has become a developed nation without outside aid programs; and a comparison of Mexico and Bolivia, which have experienced social revolution, and their respective neighbors, Guatemala and Peru, would be illuminating. Anthropologists like holistic descriptions of cultures and nations, each in its own terms: but like others, anthropology is first of all a comparative science, which appears in this book to have been forgotten.

SOL TAX
Department of Anthropology, University of Chicago

Becoming More Civilized. A psychological exploration. Leonard W. Doob. Yale University Press, New Haven, Conn., 1960. xii + 333 pp. $6.

This is a grave, warm, and ambitious book about an important set of problems relating to the very rapidly changing statuses of most of the peoples of the world. The term "civilized" refers to the industrial complex of the West (ethnocentrically excluding Japan). The author's problem is to construct likely hypotheses and, where possible, either to test them or to provide some kind of background argument for their validity, concerning differences among the "unchanged," the "changing," and the "changed." He draws on a mixed bag of materials and does not articulately recognize the differences in level among them. These are his own test materials on exigent samples in Jamaica and in three parts of Africa; test materials used by some anthropologists and psychologists working with other less civilized peoples, principally American Indian; summary statements about the nature of cultural change, in general and in reference to some particular tribes; his own informal and uncodified experiences in Africa and Jamaica (in which he shows perceptive appreciation of cultural detail), and a certain very meager amount of psychological theory.

The results are equally heterogeneous. His criticism of the adequacy of any tests, his own and those he quotes, shows the expectable high ability of a

trained social psychologist to enter caveats at every possible point, most of them well made. But the book has suffered throughout from the unsystematic inclusions of such variables as culture—in the sense of the specific culture of a given tribe—the social situation, both in macrocosms and micrososmic terms, and the general disjuncture between the minute analyses of a large number of detailed and inconclusive results and ambitious set of very general hypotheses. Although the material is too fragmentary to be anything but suggestive, it does reinforce the very strong probability that a continuum from uncivilized to civilized, even though it expresses the views of the industrialized West and the aspirations of most of the people in the world, is not a satisfactory frame of reference. Both individual cultures and individual social systems and particular situational analyses are needed as mediating variables.

The book is raw material on the confusion about the undefined boundaries between anthropology, sociology, and social psychology, when any one of the three disciplines attempts to deal with sociocultural change.

MARGARET MEAD
American Museum of Natural History

A History of Mechanics. René Dugas. Translated by J. R. Maddox. Editions du Griffon, Neuchatel, Switzerland (Central Book Company, New York), 1955. 671 pp. Illus. $15.

Mechanics in the Seventeenth Century. René Dugas. Translated by Freda Jacquot. Editions du Griffon, Neuchatel, Switzerland (Central Book Company, New York), 1958. 612 pp. Illus. $15.

A natural reaction to any new book on the history of mechanics is to compare it with Ernst Mach's work, which first appeared in 1883 and which is now a historical document. Mach's arrangement was topical, and his discussion of meaning was directed toward a philosophy of knowledge. In *A History of Mechanics*, Dugas is more purely historical. "We have preferred here to follow the elementary order in time" (page 12). In the foreword, Louis de Broglie states the difference in these words: "Certainly, the reading of Mach's book, so full of original ideas and profound comments, is still extremely instructive and absorbing. But Dugas' history of mechanics has the advantage of being less systematic and more complete" (page 8). Mach presented us with a textbook of mechanics based on its history; Dugas provides a well-selected and copiously annotated sourcebook. Almost one-third of it is devoted to developments in this century. Here, Dugas changes his method and divides each chapter into two parts: presentation, and analysis and interpretation.

The task of the translator must have been quite difficult, and in some places it was too difficult for him. This may diminish the reading pleasure, but leaving obvious criticism aside, it may also induce attempts to substitute better versions: for example, for the very last sentence of this book: "Poincaré thus gave his adhesion to the theory of relativity" (page 650).

In *Mechanics in the Seventeenth Century*, Dugas expanded, about sixfold, part 2 of his earlier volume, but the multiplication is not uniform. Thus, Descartes now is given 85 pages against 15 in the previous volume; Newton almost 100 against 18; and Leibniz about 60 against only 3. Dugas admirably carried out his intention to give "not . . . science romanticized, but the romance itself of science" (page 15). He did not even write separate biographical notes, but lets the character of the authors reveal itself in quotations and polemics. The spirit of the 17th century comes alive in the words of these men and in the description of their experiments. We experience "the romance itself of science" when we read about Pascal's experiment with glass tubes that were 40 feet in length (page 211), and we try to visualize how he handled them, one filled with water, the other with wine, to build his barometer which was attached to the mast of a ship.

Naturally, the story could not be strictly confined to the 17th century. A glimpse of the antecedents and of the radiations into the next century was necessary.

What Louis de Broglie says about this book is valid for its companion as well: "It will appeal not only to those who love the history of science, but to all those who are interested in the painful but magnificent processes of the human mind in its search for truth" (page 11).

EDUARD FARBER
4530 Brandywine Street, NW, Washington, D.C.

Galileo and the Scientific Revolution. Laura Fermi and Gilberto Bernardini. Basic Books, New York, 1961. x + 150 pp. Illus. $3.50.

The Watershed. A biography of Johannes Kepler. Arthur Koestler. Doubleday, Garden City, N.Y., 1961 (available to secondary school students and teachers through Wesleyan University Press, Columbus 16, Ohio). 280 pp. Illus. $0.95.

Michelson and the Speed of Light. Bernard Jaffe. Doubleday, Garden City, N.Y., 1961 (available to secondary school students and teachers through Wesleyan University Press, Columbus 16). 197 pp. Illus. $0.95.

Faraday as a Discoverer. John Tyndall. Introduction and notes by Keith Gordon Irwin. Crowell, New York, 1961. xvii + 215 pp. Illus. $2.75.

The Fermi-Bernardini volume on Galileo is a delightful and remarkable product of the revolution occurring in our own day, under the impact of such science historians as I. B. Cohen, Marshall Clagett, Anneliese Maier, and A. C. Crombie, in the mode of approach to the history of science. *Galileo and the Scientific Revolution* is as fresh and invigorating a work in the field of science biography as was its hero in his day in the fields of physics and astronomy. It may well be regarded as the first sound, objective, and truly analytical evaluation of a great mind that left its mark on history by giving it two twists—one in the realm of motion which cleared past confusions, the other in the employment of the telescope which opened up vast horizons. Gone is the old and naive, teleorationalist conception of man's road to scientific knowledge upon which strode determinedly the lowly but just seekers after truth, only to be badgered and mocked by the demonic agents of evil. As this little book so lucidly and concisely relates, the actual road is far more complex than that, more beset with unseen bumps and curves, yet far more intriguing and fascinating than the simple-minded portrayals of the past indicate.

The book is charmingly written in simple, direct, and absorbing style, without fanfare or emotionalism, thus placing the burden of both drama and judgment upon the reader's enriched and stimulated mind. It adheres strictly to the facts securely established, avoiding such juvenile pitfalls as the postulation of trickeries or forgeries with which to explain away deep-seated

fountainsprings of human conflict and disharmony. This book is indeed a great achievement not only as a biography of a man consistently mishandled in the past but also as an approach to biographical writing in general. It is not meant to be an exhaustive or definitive study, but it presents an excellent overview of all the acts in the rich Galileo drama.

The Watershed is a reprint of the section on Kepler in Koestler's larger *Sleepwalkers*, which appeared in 1959. It is the liveliest, most scholarly, and best part of that excellent work, and it may well go down in history as the keenest pioneering achievement in depth analysis of a scientific genius, as well as of the nature of progress in science. By utilizing his great gifts as literary master and his powers of insight into the recesses of the human mind in the throes of conflicting beliefs and loyalties, Koestler succeeds in laying the foundation for a new psychology of science, fashioning it into a discipline that combines dissection of the personality of the scientist, the culture of the time, as well as the salient ideas seeking to enter the web of prevailing beliefs, and the diverse interplay of all these factors. The result of this technique is tremendous in its power, and the light it sheds proved to be so brilliant that many pedants in the field were blinded by its glare.

The Watershed makes most fascinating reading. Koestler shows such vast knowledge of the subject, both historically and scientifically, that one doubts whether much can be added. The reader will never forget the other-worldly charm of Kepler, the depths of his feverish brainstorms, the scope of his creativity, and finally the element of historical irrationality in scientific progress, which irritated so many of Koestler's critics, and the bewildering cross-currents of thought that shaped the womb of the scientific revolution. This is a great book, a landmark in biography which no student of science or history can afford to postpone reading.

By comparison with these two biographies, Jaffe's book on Michelson seems run-of-the-mill. It is, however, an honest and thorough account of the life and work of a great physicist; it is well written, readable, and free from biographitis, if one may so describe the needless hawking which often afflicts worshipful biographers.

The reprinting of Tyndall's work on Faraday is a happy symptom of the revival of interest in the full scope of the history of science. As Faraday's associate and successor to the superintendency of the Royal Institution of London, Tyndall discusses primarily Faraday's vast and basic contributions to science in his unique manner, famed for lucidity. His few anecdotes of his personal relations with Faraday help considerably to enliven the portrait of this key figure in modern physics.

MARK GRAUBARD
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Sahara, Desert of Destiny. Georg Gerster. Translated by Stewart Thomson. Coward-McCann, New York, 1961. xi + 302 pp. Illus. + maps. $5.

Gerster's *Sahara* is a prize package of its kind. An awesome mass of factual information, sparingly sprinkled with misinformation, is presented so skillfully that the book is as enjoyable to read as a good novel. Unfortunately, in the sections dealing with prehistory and native customs, fact is mixed indiscriminately with fantasy. Specialists will heave many a weary sigh as they encounter tediously obsolete and confused theories concerning rock paintings and camels, the Hyksos and the Garamantes, the feudal matriarchal free-loving Tuareg and such. Arabic words often defeat the author utterly. For example, *Sah'ra* does not mean "mouse-coloured" but "a desert habitable in spots," a *Gandourah* by definition cannot have a hood, and *Davel Askri* is certainly a strange rendering of *Dar el Askri*. Curious factual errors occasionally creep in too. It is stated that "the early palaeolithic" only "goes back some eight to fifteen thousand years" although "the Early Stone Age" may go back "hundreds of thousands"; Rene Caillié (misspelled Caillé as usual) is said to have been "the first European to reach Timbuctoo"; and so on.

But all of this is relatively unimportant. The immediate future of the Sahara is a matter of rapidly increasing urgency because of the major roles that Moslem Africa and the Mediterranean are beginning to play in the struggle for survival of the West. In this context Gerster shines as a singularly penetrating political and economic analyst.

Water is, of course, the main thing in the Sahara. Obviously even the most primitive native communities cannot live without it, while oil drilling installations consume such enormous quantities that they depend on the discovery of new and practically inexhaustible reservoirs of water. This situation poses a whole series of problems which are clearly explained and discussed most entertainingly.

The bulk of Gerster's book is devoted to the consideration of these and other natural resources. Search, discovery, and exploitation are described minutely and as painstakingly evaluated, all in an easy-flowing style that makes them fascinating. And if the author hasn't heard that the discovery of diamonds near Silet was a hoax, it hardly matters.

Gerster goes on to discuss the impact of modern industrial expansion on native institutions. He closes with a searching and impartial examination of the perilous problems of a near future in which conflicting forces of political aspirations and economic necessity will become increasingly difficult to reconcile.

For students of political science, economics, and human and industrial geography, this book is a real goldmine. Nor can any reader, regardless of prejudice, help but be lost in admiration for the author's forthright and yet charitable objectivity. *Sahara* is a really valuable and palatable contribution in the critical fields of international and inter-religious political economy.

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Aedes Aegypti (L.), the Yellow Fever Mosquito. Its life history, bionomics, and structure. Sir S. Rickard Christophers. Cambridge University Press, New York, 1960. xii + 739 pp. Illus. $14.50.

The yellow fever mosquito, *Aedes aegypti*, is one of the insects most widely known to science. It is not only an easily used laboratory animal, but its great significance in past and present public health problems is undisputed. Sir Rickard Christophers' book comprises, under one set of covers, the most exhaustive treatment of any one insect species ever published, and its subject matter is especially appropriate.

An introductory series of chapters treats the historical significance, systematic position, medical importance, and control of *aegypti* and provides an account of the techniques used in its study. Beginning with the egg, the major portion of the book discusses the structure, physiology, development, and bionomics of each life history stage. Various phases of the discussion are illustrated clearly and simply; although only 86 figures are used, many of them are comprised of not a few separate drawings.

One of the book's major contributions is the lavish use, in the text and concluding bibliographies, of the world literature. In a day when the recording and retrieval of information becomes more and more beyond the time and individual energy of the working biologist, such a complete and orderly presentation of references is a very real boon. This is especially true for an insect such as *A. aegypti*, which is the object of the study of so many professionals in the field of entomology and public health. Appropriate references appear at the end of each chapter; they are keyed in the text by author and date and are grouped according to the subject matter to which each applies.

A work of such magnitude has obviously taken years to reach a publishable stage, and errors are of course inevitable. Despite whatever shortcomings have been pointed out by other reviewers, Sir Rickard is to be commended for the great service he has performed in presenting, summarizing, and interpreting the world's knowledge of this important mosquito.

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Practical Microscopy. C. L. Duddington. Pitman, New York, 1960. x + 237 pp. Illus. $6.50.

This book, based on lectures given at "The Polytechnic," is intended to provide other students and amateurs information for self-training to meet the paramount need "to be satisfied with nothing less than a perfect image." The standard techniques for bright-field microscopy are given in an elementary manner. Phase, interference, and electron microscopy are only mentioned. In a departure from the usual guides, the short chapter on buying a microscope calls to attention magnification and resolution requirements and the hazards of second-hand instruments. In addition to centering and lighting for good seeing, simple counting, measuring, and drawing techniques are described. Photomicrography receives brief treatment. Over a third of the book is given to simple methods for preparing animal, plant, bacteria, textile fibers, hairs, and food and drug specimens. Formulas for common fixing fluids and staining solutions and an index are included.

In the main British students are given much the same introduction as students in this country. The instruments discussed here are mostly British; the British still use turntables for liquid mounts, and the Venetian turpentine mountant is advocated. Köhler is misspelled, and the German word *xylol* is used throughout. High school science students, adult amateurs, and college freshmen should find the book helpful and readily readable.

OSCAR W. RICHARDS
American Optical Company, Southbridge, Massachusetts

Reprints

Advanced Euclidean Geometry. An elementary treatise on the geometry of the triangle and the circle. Roger A. Johnson. John Wesley Young, Ed. Dover, New York, 1960. 332 pp. Illus. $1.65.

Adventures with the Missing Link. Raymond A. Dart. Viking, New York, 1961. 280 pp. Illus. $1.65.

Algebraic Equations. An introduction to the theories of LaGrange and Galois. Edgar Dehn. Dover, New York, 1960. 219 pp. Illus. $1.45.

Animal Treasures. Ivan T. Sanderson Viking, New York, 1961. 330 pp. Illus. $1.45.

Auguste Comte and Positivism. John Stuart Mill. Univ. of Michigan, Ann Arbor, 1961. 200 pp. $1.75.

Calculus of Finite Differences. George Boole. J. F. Moulton, Ed. Chelsea, New York, ed. 4, 1961. 348 pp. $1.39.

Calculus of Variations. A. R. Forsyth. Dover, New York, 1960. 678 pp. $2.95.

Causality and Chance in Modern Physics. David Bohm. Harper, New York, 1961. 181 pp. $1.35.

Characterisation of Organic Compounds. F. Wild. Cambridge Univ. Press, New York, 1960. 314 pp. $2.95.

The Dancing Bees. An account of the life and senses of the honey bee. Karl von Frisch. Translated by Dora Ilse. Harcourt, Brace, New York, 1961. 192 pp. Illus. $1.95.

Frustration and Aggression. John Dollard *et al.* Yale Univ. Press, New Haven, Conn., 1961. 217 pp. $1.25.

Genetics Is Easy. A handbook of information. Philip Goldstein. Viking, New York, 1961. 253 pp. Illus. $1.45.

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The Image. Kenneth E. Boulding. Univ. of Michigan Press, Ann Arbor, 1961. 175 pp. $1.65.

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Introduction to the Theory of Linear Differential Equations. E. G. C. Poole. Dover, New York, 1960. 210 pp. $1.65.

The Life and Death of Cells. Joseph G. Hoffman. Doubleday, New York, 1961. 354 pp. $0.95.

Man-Made Sun. J. D. Jukes. Viking Press, New York, 1961. 136 pp. $1.25.

The Mechanism of Evolution. W. H. Dowdeswell. Harper, New York, 1960. 125 pp. Illus. $0.95.

A Modern Introduction to Logic. L. S. Stebbing. Harper, New York, 1961. 543 pp. Illus. $2.75.

Natural Selection and Heredity. P. M. Sheppard. Harper, New York, 1961. 209 pp. Illus. $1.35.

The Nature of Thermodynamics. P. W. Bridgman. Harper, New York, 1961. 248 pp. $1.40.

One, Two, Three . . . Infinity. Facts and speculations of science. George Gamow. Viking, New York, 1961. 352 pp. Illus. $1.65.

The Origin of Species by Means of Natural Selection: Or the Preservation of Favored Races in the Struggle for Life. Charles Darwin. Doubleday, Garden City, N.Y., 1961. 517 pp. $0.95.

The Outermost House. A year of life on the great beach of Cape Cod. Henry Beston. Viking, New York, 1961. 236 pp. Illus. $1.25.

Photoelasticity. Principles and methods. H. T. Jessop and F. C. Harris. Dover, New York, 1961. 192 pp. Illus. $2.

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Readable Relativity. Clement V. Durell. Harper, New York, 1960. 157 pp. Illus. $1.25.

Religion and Science. Bertrand Russell. Oxford Univ. Press, New York, 1961. 256 pp. $1.25.

Reports

Purification of Antibody to Galactosyl-Protein Conjugates

Abstract. A rapid procedure for purification of rabbit antibody to β-D-galactosylphenylazo-bovine serum albumin is described. Antibody was precipitated with a heterologous antigen and was then dissociated from the precipitated complex with hapten. The antigen was partially removed by *p*H adjustment, and antibody was separated from residual antigen and from hapten by partition chromatography on Sephadex G-25. The antibody, obtained in 50 to 55 percent over-all yield, was 96 percent reactive with homologous antigen. It appeared to consist of 95 percent of a single component, based upon physicochemical measurements.

In connection with work on biosynthesis and location of the combining regions of rabbit antibody to the β-D-galactosyl group, it became necessary to seek facile methods for the preparation of highly purified material. Several procedures which had previously been devised (*1*) for obtaining antibodies in a relatively pure state were employed, but were not applicable to this system because of poor resolution of protein and because of low over-all yields. The method reported here takes advantage of the ease of dissociation of a heterologous antigen-antibody precipitate by the hapten *p*-nitrophenyl-β-D-galactoside and uses the finding (*2*) that substances of low molecular weight may be separated from more complex molecules by chromatography on a Sephadex column. Heterologous precipitating antigens have been used previously in other procedures (*3*) for the purification of antibodies.

The immunizing antigen was prepared by coupling *p*-aminophenyl-β-D-galactoside to bovine serum albumin (BSA, Armour fraction V) by diazotization, as previously reported (*4*). Analysis of this purified conjugate by the anthrone method demonstrated that 17 sugar residues were attached per mole of bovine serum albumin. The precipitating antigen was synthesized by treating human serum albumin (*5*) in the same fashion. It contained 13 moles of bound sugar per mole of protein. The heterologous precipitating protein, under comparable conditions, removed 60 to 65 percent as much antibody from solution as the homologous antigen did.

An antiserum was obtained from rabbits immunized with alum-precipitated antigen. It contained 100 mg of antibody precipitable by galactosylphenylazo–bovine serum albumin. After absorption of this antiserum with bovine serum albumin to remove antiprotein antibodies, 14 mg of the heterologous antigen was added to the supernatant. After incubation at 37°C for 1 hour, the mixture was cooled to 4°C for 3 hours. Prolonged incubation in the cold at this point did not materially increase yields. The resultant precipitate was removed by centrifugation and was washed with phosphate buffer (*p*H, 6.8; Γ/2, 0.05) several times with thorough mechanical suspension in order to remove nonspecifically adsorbed protein. This antigen-antibody complex was then dissociated by incubating for 0.5 hour at 37°C with 2 ml of 0.05*M* *p*-nitrophenyl-β-D-galactoside. The precipitate dissolved completely. Since it was found that borate ions, when added at this point, aided in the removal of precipitating antigen, 1 ml of 0.1*M* boric acid was added, and the *p*H was lowered to 4.7 in the cold with 0.1*N* HCl. The mixture was centrifuged at 5°C at 2000 rev/min for 1 hour to separate the antigen.

A Sephadex G-25 (Pharmacia, Uppsala, Sweden) column, 30 by 2.5 cm, was prepared by addition of 25 g of the cross-linked dextran polymer to phosphate buffer (*p*H, 6.8; Γ/2, 0.05). After the column had stood overnight, it was washed with buffer until absorption in the ultraviolet at 280 mμ could no longer be detected in the washings. The supernatant solution, after removal of antigen as described above, was placed on top of the column, and the chromatogram was developed in the cold room with the phosphate buffer. Column effluent was collected in 10-ml portions, and the appearance of protein in the fractions was checked by ultraviolet absorption measurements. The antibody appeared as a sharp peak in the 70- to 90-ml volume of effluent. Residual antigen and *p*-nitrophenyl-β-D-galactoside were not eluted until several hundred milliliters of phosphate buffer had been run through the column. Complete resolution of hapten from antibody combining sites was demonstrated by examination of the fractions containing antibody for the chromogenic hapten by the usual hydrolysis and alkaline color test for *p*-nitrophenolate anion. It was not possible to detect any hapten by this procedure. After all ultraviolet-absorbing material had been removed by washing with excess buffer, the column was suitable for another chromatographic run. The total recovery of purified antibody was 50 to 55 mg in several experiments. This was an almost quantitative yield in the steps involving solubilization of antibody with hapten and removal of impurities by Sephadex chromatography.

The resultant antibody was examined by sedimentation and electrophoretic analyses (*5*). It was shown that 95 percent of the protein had a sedimentation constant of 6.45, while the remainder, probably a macroglobulin, had a constant of 18.9 *S*. The electrophoretic mobility was typical for a γ-globulin, although some spreading after 3 hours, probably due to the presence of the macroglobulin (*6*), was seen. Immunoelectrophoresis of the antibody against sheep anti-rabbit serum indicated a single component, and no non-γ-globulin impurities were detected. The addition of increasing amounts of homologous antigen to the purified antibody showed that 80 percent of the total protein was specifically precipitated at the maximum point. The supernatant from this precipitation was tested (*7*) for the presence of nonprecipitating antibody by coprecipitation with an additional known amount of antigen and precipitating antibody. Another 16 percent of the initial protein present was recovered by this procedure, so that 96 percent of the purified antibody solution could be specifically reacted with homologous antigen.

In addition to high resolution and yield of antibody, this procedure is advantageous because of the minimum number of manipulations involved.

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* **125**, 16 (1957)].

Time-consuming dialyses, which often result in a considerable degree of protein denaturation, are thus avoided. At present this method is being tested with other anti-hapten systems (*8*).

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23 January 1961

Age Changes in Adenine Nucleotides in Flight Muscle of Male House Fly

Abstract. Under standard conditions of temperature, humidity, and (artificial) diet, loss in flight ability is paralleled by a decline of up to 66⅔ percent in activity of enzymes dephosphorylating organophosphorous compounds in the thoracic flight muscle. Concomitantly, the content of adenosine triphosphate in the flight muscle increases five times, while the content of adenosine monophosphate correspondingly diminishes.

In an earlier paper, Rockstein reported (*1*) that the male house fly, *Musca domestica* L., reared and maintained under standardized conditions of temperature, humidity, and artificial diet, consistently demonstrated failure in flight function in the form of abrading and (ultimately) loss of its wings beginning with the 10th and usually by the 14th day of adult life. Concomitant biochemical changes were also observed in the form of marked decline in the activity of sodium β-glycerophosphatase activity from five activity units at 1 day to 1.8 units by the 11th day. Follow-up determinations of activity in the thoracic flight muscle of magnesium activated adenosine triphosphatase, by the method of Sacktor (*2*), have shown a remarkably similar decline in the activity of this enzyme, both in total thoracic homogenate extracts as well as in the flight muscle mitochondria per se, especially after the 9th to 10th day.

In order to explore further the biochemical manifestations of the senescence in flying ability of the male house fly, we undertook to determine what changes might be taking place in the substrate of this important enzyme system, adenosine triphosphate and its breakdown products, in the aging flight muscle of the male fly. Flies of known age of the NAIDM (*3*) strain were anesthetized lightly with CO_2, sexed, and frozen solid by rapid plunging into liquid air. For each age, 50 thoraces were isolated and ground in cold 0.6*N* perchloric acid in an Elvehjem-Potter (Teflon and glass) homogenizer. This and all other subsequent procedures preparatory to chromatographic separation were carried out at approximately 0°C. The total homogenate was transferred quantitatively to a centrifuge tube and centrifuged at 2000*g*. The supernatant liquid was set aside and stored cold, and the centrifugate was resuspended in cold 0.2*N* perchloric acid and recentrifuged. The combined supernatant liquids were then neutralized with 5*N* sodium hydroxide and transferred to a Dowex 1-X 10 (200 to 400 mesh) ion-exchange resin column (1 by 6 cm), previously prepared in the formate form, according to the Siekevitz-Potter method (*4*). By the modified Carter and Cohn gradient elution technique (*5*), we separated the three adenine nucleotides, with adenosine monophosphate and adenosine diphosphate being eluted by the distilled water–4*N* formic acid system and adenosine triphosphate by a similar formic acid–0.6*N* ammonium formate in 4*N* formic acid system (*6*). Estimation of each nucleotide was made by absorbance at 260 mμ, in the Beckman DU spectrophotometer. Standard solutions of each of these nucleotides were run through the column once weekly to check the consistency of this fractionation system. By this method, adenosine monophosphate was eluted completely in the 6th to 15th (5 ml) collecting fractions, adenosine diphosphate between the 30th to 50th tubes, and adenosine triphosphate in tubes 75 to 90.

Table 1 shows that the content of adenosine triphosphate in the thorax of the male house fly rises significantly after the 1st week and reaches a maximum value by the 9th day, that is, at a time when the enzyme system involved in its dephosphorylation approaches a minimum. Concomitantly and reciprocally, the content of adenosine monophosphate (the breakdown product of adenosine triphosphate) reaches a minimum level. These biochemical manifestations of senescence of flight ability all reflect morphological and gross functional alterations with age in flying ability at the virtually identical point in the life history of the male fly. The recognized role of phosphorus metabolism in general and the dismutation of "high-energy" bonds in the energizing of a number of important biological processes, including muscle contraction (*7*), make these correlative positive observations of a quantitative nature highly gratifying in an area where more and more concrete evidence of a fundamental biological phenomenon (like senescence) is being sought after. In order to pinpoint the actual sites of such changes within the flight muscle itself, current investigation is being made of biochemical changes and concomitant changes in the cytochemical-cytological features of the giant mitochondria (sarcosomes), the fibrillar, and the soluble fractions of the flight muscle of the aging house fly. Preliminary findings point strongly to the primary role of a declining intramitochondrial enzyme and an extramitochondrial site of the changing adenine nucleotide content (*8*, *9*).

Table 1. Adenine nucleotides in the flight muscle of aging male house flies, *Musca domestica* L. Amounts are expressed in absorbance units per total extract from 50 thoraces, at each age level. AMP, adenosine monophosphate; ADP, adenosine diphosphate; ATP, adenosine triphosphate.

Age	AMP	ADP	ATP
0–2 hr	3.9	1.2	1.0
6–8 hr	4.4	1.1	0.7
22–24 hr	5.7	0.8	1.6
44–48 hr	5.3	0.9	0.8
3–4 day	4.9	0.4	0.6
4–5 day	6.6	0.5	1.9
6–7 day	4.6	1.6	2.7
8–9 day	1.2	2.0	6.7
12–13 day	1.8	2.2	5.2
14–15 day	1.7	1.8	5.2
15–16 day	1.1	1.3	6.2

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9. We wish to acknowledge that this work was supported in part by a grant (RG-7099) from the National Institutes of Health, U.S. Public Health Service, and a research grant from the New York University School of Medicine honors program. We are deeply appreciative of the kind advice and many suggestions made by Philip Siekevitz of the Rockefeller Institute and by Robert Chambers of the New York University Medical Center department of biochemistry, in connection with the differential elution–chromatographic separation procedures.

5 January 1961

Ether-Induced Retrograde Amnesia for One-Trial Conditioning in Mice

Abstract. Mice were tested in a situation permitting them to step readily from a small, restrictive platform to a larger one. Conditioned avoidance was established by a single training trial when animals received a shock by stepping from one platform to another. At various intervals after the single punishing shock, subjects were anesthetized with diethyl ether. Interference with retention, tested 1 day later, was shown for intervals up to 24 minutes, at which time ether no longer appeared to influence the subsequent response.

Several recent investigations (*1*) have suggested that anesthetic agents have an interfering effect upon the retention of recently acquired memories. The rationale underlying such studies has been that certain agents disrupt the consolidation of the memory trace. One such agent which also causes a depression of neural activity is diethyl ether. The purpose of the present study was to investigate the effect of anesthesia introduced at various intervals after a single conditioning trial on retention.

One hundred and twenty male Swiss-Webster mice, approximately 28 days old, were randomly assigned to six experimental and six control groups of ten subjects each. All animals were conditioned to inhibit a stepping response from a small restrictive platform to a larger platform below in order to avoid a shock. The small platform, measuring 1¾ by ⅞ in., was lowered to the larger platform, measuring 6 by 6 by ¾ in., by means of a ½-in. metal rod connected to a pinion gear arrangement; each animal was lowered from a height of 4 in. to within ⅜ in. of the lower platform. Animals received a painful electric shock of approximately 3 ma from a 270-volt d-c source when they stepped to the lower platform. Subjects in each of the six experimental groups were anesthetized in a beaker with diethyl ether at intervals of 0, 2, 8, 16, 20, or 24 minutes after the conditioning trial and were allowed to recover in their home cages. Anesthetic induction took approximately 40 seconds. Subjects in the six control groups were confined to an empty beaker for 10 seconds after delays equal to those of the experimental subjects; then they were returned to their home cages without etherization.

A testing trial for the retention of the conditioned avoidance response was performed 24 hours after the training trial. Conditions were identical with those of the training trial except that the platforms were not electrified. Response latencies were recorded for all subjects, and those animals not moving from the upper platform within 30 seconds were removed by hand.

To test for any possible effects of ether anesthesia on the unconditioned response, two groups of ten subjects each were allowed to respond on the platform apparatus in the absence of shock. One group was anesthetized with diethyl ether immediately after responding, whereas the other group was treated in the same way as the controls described above. These animals were tested 24 hours later.

Figure 1 shows the experimental and control response latencies as a function of the training-anesthesia interval. A conditioned response was defined as any response with a latency longer than 10 seconds. A chi-square analysis for the frequency of conditioned responses yielded a value of 22.70 between the experimental and control groups; this value is significant beyond the .001 level of confidence. The response latencies for the unshocked control groups were not significantly different, with none of these exceeding 2.1 seconds.

The data clearly support the hypothesis that ether anesthesia has an interfering effect on the retention of a conditioned avoidance response in the mouse. The fact that all of the untreated control subjects increased their response latencies from a median of 1.41 seconds on training to 30+ seconds on testing suggests that conditioning has certainly taken place.

The ether anesthesia was effective in interfering with retention in 100 percent of the subjects in the 0-, 2-, and 8-minute groups, 60 percent of the subjects anesthetized 16 minutes after training, 50 percent of the 20-minute group, and only 20 percent of the group treated 24 minutes after training. At this time the median response latency was again 30 seconds.

The concept of the consolidation process has been proposed (*2*) to account for the changes in neural activity which follow a behavioral event. The hypothesis states that during this period the memory trace from the original event perseveres and hence may be affected by the introduction of various chemical and other agents and by given environmental events.

The results of the present experiment suggest that anesthesia with diethyl ether will completely impair the retention of the conditioned avoidance response if it is administered within 8 minutes after training, will impair the retention less if administered from 16 to 20 minutes after training, and will not significantly affect retention if administered 24 minutes after training. A previous study (*3*) has shown that

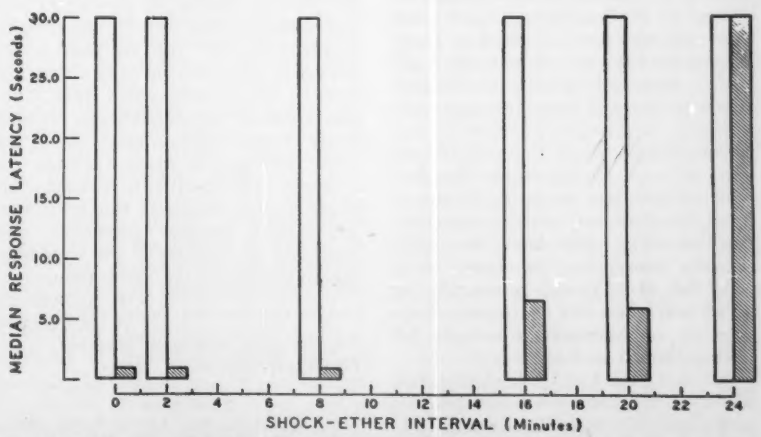

Fig. 1. Median response latencies for control and experimental groups. Open rectangles, control group; crosshatched rectangles, experimental group.

diethyl ether given to mice 1 hour after a single-trial conditioning situation will not impair the retention of a response tested 24 hours after training. This observation, supported by the results of another study employing ether anesthesia in rats (*4*), leads one to infer that consolidation is complete between 20 and 24 minutes after training in this type of situation (*5*).

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Detection of Lycopene in Pink Orange Fruit

Abstract. Lycopene is shown to be the pink coloring pigment in Sarah—a pink sport of the Shamouti (Jaffa) orange—together with other unidentified carotenoids. This is a condition similar to that found in pink and red grapefruits, while the red pigments of blood oranges are anthocyanins.

Matlack (*1*) had suggested that the red coloration in blood oranges is caused by anthocyanins, which have quite recently been identified as cyanidin-3-glucoside and delphinidin-3-glucoside, dissolved in cell sap of juice vesicles of some blood orange varieties (*2*).

On the other hand, the pink and red color of some grapefruit and shaddock varieties has been found to be caused by plastid-contained lycopene and beta-carotene (*3*), which have been quite recently investigated by Lime *et al.* (*4*), Purcell (*5*), and others. As far as we are aware (*6*), no report of the presence of lycopene in oranges has been published to date.

Sarah, a pink bud sport of Shamouti (Jaffa) orange, which was first detected in the late 1930's and described in 1944 (*7*), presents at an even superficial examination many of the characters of pink grapefruits: (i) the filtered juice is almost colorless and does not present any pink tinge; (ii) the pink color is mainly present in the inner mesocarp, carpel walls, and vesicle stalks; and (iii) large concentrations of dark-yellow to pink plastids are detected especially around main conducting bundles and their anastomoses (*8*) even when fruit is fully ripe.

Carpels of ripe Sarah fruits were blended, extracted, and chromatographed on 1:1 W/W Magnesia-Hyflo Super Cel columns, as described under method A, by Lime *et al.* (*4*).

Two main bands were obtained, an upper red and a lower yellow-orange, which were eluted with 10 percent acetone in hexane and 5 percent methanol in hexane, respectively, into two separate fractions.

Spectral curves of both fractions were determined with a Beckman DU spectrophotometer. The curve obtained from the upper band was identical with that of lycopene in hexane, with peaks at 445, 470, and 503 mμ. This is in accordance with the situation found in pink and red grapefruits (*4*, *5*). The second fraction which had been found to contain only beta-carotene in grapefruits (*4*) did not yield a curve identical with that of beta-carotene in hexane, since it has peaks at 440, 470, and 500 mμ instead of two peaks at 455 and 480 mμ (*4*); it seems to contain some unidentified carotenoids.

No anthocyanins could be detected in the aqueous and methanolic extracts of Sarah carpels or mesocarp portions. It is therefore concluded that the pink coloration observed is induced by substantial amounts of lycopene and not by anthocyanins as is usual in blood oranges.

Purcell (*8*) has pointed out that a carotenoid precursor must be assumed to enter fruit through the vascular system and to diffuse into the surrounding parenchyma where it produces pink coloration in pink and red grapefruits, especially before full ripeness is attained. It seems worth adding that this must be true for most citrus fruits. Concentrations of carotenoids can be seen easily around bundles, especially at the main fruit axis in many varieties, for example, Shamouti and Valencia oranges, Dancy tangerine, Eureka lemon, and Marsh seedless grapefruit, and especially so, because of the emphasizing pink tinge, in the Sarah orange.

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A World-wide Stratospheric Aerosol Layer

Abstract. An aerosol layer has been identified by a stratospheric balloon and aircraft aerosol collection program. Measurements of horizontal extension and vertical distribution indicate that this layer is a world-wide phenomenon, displaying little variation with time and latitude. The particles in this layer range in size between 0.1 and 2 μ in radius, are water soluble, and contain sulfur as the predominant constituent. It is most likely that they are formed within the stratosphere.

A program of stratospheric aerosol collection with high-altitude balloon equipment was started about 3 years ago and was recently supplemented by collection with high-altitude aircraft (*1*). The aim was to obtain basic information on a heretofore neglected subject of some importance to radioactive fallout and stratospheric circulation studies. The instrumentation was designed to study vertical profiles of number concentration of two particle size ranges, as well as the horizontal distribution, size distribution, and chemical composition of the particles. It is evident, from the results now available, that a large, persistent aerosol layer exists in the stratosphere at an altitude of about 20 km. This layer is composed of particles between approximately 0.1 and 2 μ in radius. Particles smaller than 0.1 μ are distributed with entirely different vertical profiles, the form of which indicates that they are of tropospheric origin and are brought into the stratosphere by mixing. On the other hand, a 2-μ radius appears to be a rather sharp upper limit, and almost no particles larger than this seem to be present. The characteristic features of this aerosol layer are listed below.

1) Vertical profiles obtained in middle north latitudes show a very broad maximum in number concentration at altitudes between about 18 and 23 km. The number concentration of particles at this maximum is about 1 per cubic centimeter, which is higher by a factor of 3 than that at the tropopause, and in most cases decreases rapidly above 24 km. The time variation at this maximum over a period of more than 2 years does not exceed a factor of 3. The shape of the vertical profile indi-

cates that it is most unlikely that these particles have penetrated into the stratosphere from the troposphere by vertical mixing.

2) Collections of these particles by aircraft at about 20 km over a wide range of latitudes between about 40°S and 70°N over a period of more than half a year show that the particle concentration is remarkably uniform with time and latitude. The combination of these aircraft data with the vertical profiles obtained in middle north latitudes suggests that the aerosol layer is a world-wide, persistent phenomenon.

3) The size distribution, dn/dr, of the particles between 0.1 and 2 μ in radius is of the form

$$dn/dr = kr^{-a}$$

with a being approximately 3; k is a constant. The particles are water soluble, have a tendency to evaporate to a spotty residue in the electron microscope, and show a structure and shape very much resembling those of spray aerosols produced from solutions of ammonium sulfate and some other soluble salts.

4) Analyses of the heavy deposits from long balloon and aircraft flights were performed with electron microprobe techniques and indicated sulfur to be the predominant element in the range of atomic numbers from magnesium (12) through zinc (30). The sulfur is deposited roughly in proportion to the visual density of the collection and has been present in every sample analyzed to date. Occasional samples contained aluminum, silicon, and iron. Some traces of chlorine, potassium, and calcium were found. Table 1 contains a summary of the average composition for both balloon and aircraft samples. We think that these particles consist mainly of ammonium sulfate and adduce, in addition to Table 1, the hygroscopicity of the collected particles and the electron diffraction pattern obtained by Friend (*2*), both of which indicate this compound. The few samples which have contained a significant amount of either silicon or iron, distributed throughout the collection, can be tentatively explained by a temporary fluctuation in micrometeorite influx. In no case was the concentration of either of these elements more than one-third that of sulfur on the same sample, which is in agreement with our identification of the persistent aerosol layer with a soluble sulfate. Since the vertical profile makes a direct tropospheric origin unlikely, and the composition makes an extraterrestrial origin unlikely, it appears that this aerosol must form within the stratosphere itself. The most plausible explanation at the present time is that these particles are formed by the oxidation of H_2S or SO_2 by ultraviolet radiation or ozone at the level where they are found. These gases, known to be present in the troposphere in sufficient quantity, can enter the stratosphere by mixing, without being removed very efficiently by washout in the upper troposphere.

Table 1. Chemical analysis of stratospheric particles from balloon and aircraft samples.

Balloon (0.1μ < particle radius < 1.5μ)		Aircraft (0.02μ < particle radius < 3.0μ)	
Element	Relative concn.*	Element	Relative concn.*
S	0.85	S	0.85
Si†	.08	Al†	.05
Fe†	.04	Si,Ca,K,† Fe	.01
Al‡	<.04		
Cl, K, Ca, Cr, Co, Ni, Cu, Zn ‡	<.01	Mg, P, Cl, Cr, V, Mn, Co, Ni, Cu, Zn ‡	<.01

* No allowance has been included in these figures for combined forms of elements of atomic number less than 12. † The concentration of these elements fluctuates from sample to sample. ‡ These elements were not generally present in detectable amounts.

This world-wide aerosol layer is most likely the one long sought for to explain the Purple Light (*3*). The conspicuous disk of red light above the point of sunset or sunrise has been observed for over a hundred years as a very regular phenomenon. The geometry of its appearance points to a thick aerosol layer in the stratosphere as the origin of the scattered light, although more precise calculations of the height of this layer, to be compared with our profiles, are still missing.

Thus far, our data have provided no support for the theory that rainfall is stimulated on a world-wide basis by the influx of extraterrestrial dust through the stratosphere into the troposphere. The particles of the stratospheric aerosol layer do not have the characteristics required by this theory. In addition, the presence of this aerosol layer seriously prejudices the identification of extraterrestrial dust collected at this altitude. We estimate that, in the size range below 2 μ in radius, the sulfate aerosol is about a factor of 1000 higher in number concentration than the cosmic dust, using Opik's estimate (*4*) for the latter and assuming sedimentation equilibrium in the atmosphere. It is very difficult, therefore, to detect the particles of extraterrestrial origin among the many indigenous ones. On the other hand, the concentration of particles of cosmic dust larger than 2 μ in radius is already so low that optimal sampling conditions provide an expected population of only 1 or 2 per square centimeter on the collection substrate, so that identification against background becomes a problem. If positive fluctuations of meteoritic influx in this size range exist, our data indicate that they must be rare, and it appears that a systematic aircraft collection program is the most promising method for the sampling of such swarms. Such a program is currently in operation through cooperation with the Defense Atomic Support Agency (*5*).

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Queen Honey Bee Attractiveness as Related to Mandibular Gland Secretion

Abstract. The termination of mandibular gland secretion by gland removal in living mated queen honey bees (*Apis mellifera* L.) caused approximately 85 percent loss of queen attractiveness to worker bees. The secretion of attractants in virgin queens increased with age. Old virgins were as attractive as mated queens. A rapid assay for queen attractiveness is described.

The queen bee is attractive to worker bees in the honey bee (*Apis mellifera* L.) colony. Worker bees constantly surround the queen, licking the abdomen, touching various body parts with their antennae, and offering food. Since dead queens or lipid extracts of queens are attractive to worker bees (*1*), chemical mediation of attractiveness is indicated rather than auditory, visual, or other communicative media.

It was observed in this laboratory that the contents of mandibular glands (*2*) removed from the heads of living queens were attractive to worker bees. These observations suggested that the mandibular gland secretion in living queens might be primarily responsible for queen attractiveness.

An experiment was conducted to assess quantitatively the contribution of the mandibular glands to the attractiveness of five classes of living queens (Table 1). Classes I and II were randomly chosen from normal colonies.

Table 1. Attraction of worker bees to queen bees as a function of mandibular gland secretion.

Class of queens	Queens in class (No.)	Mean ranges of attracted workers*	Mean attraction of workers*
I. Laying queens with glands	5	36–75	48.5 ± 8.4†
II. Laying queens without glands	5	2–15	7.4 ± 2.7†
III. Aged virgins with glands	5	21–69	45.7 ± 8.7†
IV. Aged virgins without glands	4	10–23	16.4 ± 3.3†
V. Newly emerged virgins with glands	5	0–14	3.8 ± 4.1†

* Means result from four replicates, with same queens for each test (only three replicates for class V queens). † 95 percent confidence intervals.

Mandibular glands were removed (*3*) from class II one day before assay. Classes III and IV were sister queens. Class III queens were confined in cages within normal colonies from emergence until the attractiveness test 28 days later. Class IV queens were treated identically, except that the mandibular glands were extirpated within 24 hours after emergence. Class V queens were taken directly from an incubator within a few hours after emergence. All queens were tested for attractiveness simultaneously.

Queen attractiveness was assayed by confining the queens singly in new, 30- by 80- by 15-mm wooden cages (queen mailing cages) having approximately 10^3 mm^2 of wire screen (1.9-mm apertures) exposure on one side. The cages were randomized and distributed immediately on their sides over the top bars of an exposed colony, so that bees had easy access to the screened area of each cage. Then the hive was closed, the cover being supported well above the cages by an empty hive body. Thus the cages were enclosed in a dark chamber free of extraneous air currents. After an exposure period of 10 minutes, all cages with adhering workers were confined in separate cardboard containers. Bees in each container were anesthetized with carbon dioxide and counted.

Striking differences were found between the attractiveness of queens with and without mandibular glands (Table 1). Mated laying queens lost a mean of 85 percent of their attractiveness because of the loss of mandibular gland secretion. The results on attraction of aged virgin queens without glands are biased since 50 percent of the population from which these queens were selected died during the 28 days preceding the attractiveness test. The survival of these confined virgin queens depended upon their capacity to attract nurse bees to feed them. Hence the survivors which were assayed probably represent the most attractive half of that population.

No significant difference (Table 1) was found between the attractiveness of aged virgin queens and mated laying queens. It is therefore concluded that the secretion of attractive materials by the mandibular gland in the queen is a function of maturation rather than mating or egg laying, or both. This is an important consideration in biochemical studies of queen attractants since virgin queens, as opposed to mated queens, can be reared and aged conveniently in quantity.

The mechanism of attraction of workers to their queen serves an important function in the social organization of the colony. Recent research (*4*) has demonstrated that bioactive chemicals are produced by the queen and disseminated to worker bees. These chemicals, known as pheromones (*5*), are potent chemical messengers which mediate behavioral and physiological responses in the workers. One orally acting queen pheromone (9-oxodec-2-enoic acid) has been identified and synthesized (*6*). One or more olfactorily acting queen pheromones from the mandibular gland secretion therefore attract worker bees to the source of orally acting pheromones which are then passed from worker to worker through food-sharing activities (*4*, *7*). The combined effects of the queen pheromone complex ultimately contribute to the integration of thousands of bees into an organized insect social community (*8*).

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Provisional Audiogram for the Shark, Carcharhinus leucas

Abstract. In an operant-conditioning study, a bull shark responded to signals at frequencies between 100 and 1500 cy/sec. In its band of greatest sensitivity (400 to 600 cy/sec), it discriminated, from high-level ambient noise, signals of amplitudes which the apparatus could not measure.

In an operant-conditioning study, which was prematurely terminated because of circumstances beyond our control, we obtained a provisional audiogram for the bull shark. To our knowledge, three precedents for the conditioning of sharks have been established. Vilstrup (*1*) conditioned spiny dogfish to a motor horn. Moulton (*2*) demonstrated the ability of the smooth dogfish, *Mustelus canis*, to associate an oscillator signal with an electric shock. Clark (*3*) showed that an instrumental (= operant) response could be elicited from large lemon sharks (*Negaprion brevirostris*).

Lowenstein and Roberts (*4*) reported an electrophysiological study of elasmobranch hearing, but expressed the belief that the frequency range derived therefrom had dubious physiological significance.

The subjects of the present experiments were a healthy male *Carcharhinus leucas* which had been captured in the spring of 1959, and a female which was introduced into the pens in the early spring of 1960. All experiments reported here were conducted in one of the 12- by 24-m shark pens at the Lerner Marine Laboratory, Bimini, Bahamas, described by Gilbert and Kritzler (*5*).

Originally, our subjects were trained to manipulate a bar near the surface of the water as the conditioned response to a motor horn signal (peak intensity at 610 cy/sec). In the course of these training exercises, and after the female of the pair had achieved a high level of performance, we became aware of the fortuitous appearance of an operant response in which both sharks demonstrated perception of the sound stimulus by abruptly terminating their normal random movements and swimming, with accelerated velocity, directly to the location of the sound source, about 6 m from the reinforcement area. Subsequent experiments, in which the sound source was moved at random with respect to the reinforcement area, confirmed that the location of the former, rather than of the latter, governed the orientation of the subjects.

The data reported here were secured by exploiting the turning and acceleration components of this orientation response; only the male was used. Attempts to capture a replacement for

the female, which died in late June 1960, were unsuccessful.

The experimental design was as follows. At the north end of the pen (immediately beneath the observers' platform) there was centered an underwater loudspeaker, about 6 m south of which was suspended a hydrophone. The stimulus, consisting of successive 2-second pure tones at the frequency and amplitude being tested, was sounded when the shark, moving *away* from the speaker, was at a distance about equal to that between the speaker and the hydrophone. Thus the signal received by the observers through the hydrophone was assumed to be equivalent to that arriving at the subject. The response was considered acceptable only when the stimulus elicited an instantaneous and vigorous 180° turn and an accelerated movement back toward the sound source. Reinforcement (consisting of a 50-g portion of fish) was given when the subject had arrived within a meter of the speaker.

The acoustic apparatus was composed of separate emitting and receiving systems. The emitting system operated satisfactorily with the exception that when, in order to compensate for rising thresholds at the limits of the shark's frequency range, it became necessary to increase greatly the output power of the system, the loudspeaker's normal sine-wave signal became severely distorted. Limitations imposed by the receiving system were more serious. Two factors precluded expressing thresholds for intensity in terms of a standard reference. First, the ambient noise in the pen was consistently at a high level. When measured on one occasion with a visitor's AN/PQM-1A noise measuring set, it averaged about 60 db above a reference of 0.0002 dy/cm^2. Thus, despite the use of an efficient filter (*6*), the subject, at frequencies within its optimal sensitivity band (400 to 600 cy/sec), discriminated signals which were below the indicated filtered noise level and were therefore not measurable. Second, we were unable to procure instruments which would calibrate the receiving system within the sensitivity range of the hydrophone or of the shark. The only reference level available, therefore, was the mean of the filtered ambient noise. This was of nearly equal intensity throughout the shark's range, during the trials reported here, and was adopted as a zero line in plotting the audiogram (Fig. 1*a*).

Each time the subject responded to a stimulus of selected frequency and amplitude, the intensity was reduced until the subject no longer responded. The points on the audiogram represent half the difference, in decibels, between the lowest amplitude at which the stimulus evoked an acceptable response and the next lower at which it did not.

The audiogram is based upon 105 trials which took place on 2 days in August 1960. The broken lines in the right and left ends of the curve denote those points at which the shark failed to respond to stimuli of such high intensity that further increases resulted in the signal distortion noted above. At the center of the curve the sensitivity of the subject exceeded that of our instruments; our ignorance of the curve's shape here is shown by the broken line. The number in parentheses besides each frequency point refers to the total trials upon which the point is based.

As noted above, the greatest single

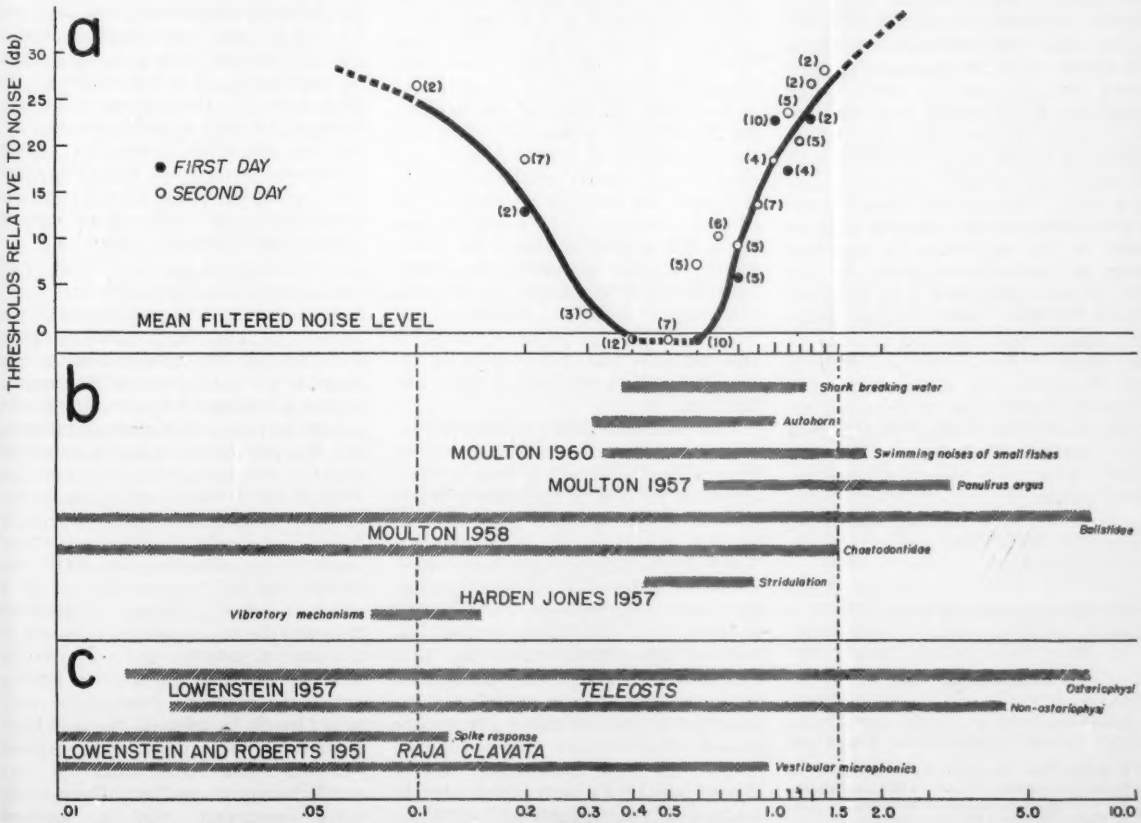

Fig. 1. (*a*) Relative auditory thresholds and frequency range of *Carcharhinus leucas*. (*b*) Spectra of sounds of the natural environment of *C. leucas*. (*c*) Auditory ranges of teleosts and one other elasmobranch.

difficulty in the present investigation was the persistence of high-level noise in the acoustic environment of the pens. Quantitative studies (*7*) of teleost audition suggest that their intensity thresholds differ little from those of man, though their optimal frequencies — like those reported here — are in a lower part of the spectrum. With an assumed noise level of about 60 db, the shark was faced with a problem in discrimination rather than the simple detection of low-intensity sounds in a sea of silence. That it was able to discriminate in the 400- to 600-cy/sec band, when the signal-to-noise ratio indicated by our equipment was *less* than unity, suggests that, if these experiments had been done in a silent environment, the shark's thresholds, at each frequency in its range, would conceivably have been as much as 60 db lower. This would modify the shark's audiogram to be more nearly approximate to those of teleosts and, hence, to that of man.

While the question of sensitivity is of basic importance, so also are two other functional dimensions of hearing. We have already mentioned our observations of these subjects' ability to localize accurately the source of sound in the water. The third consideration is the extent to which this shark's provisional frequency range is useful in the perception of its natural sonic environment. If we compare this range to the spectra of sounds in the sea which may be significant to such a predatory animal (Fig. 1*b*), we find that components of these sounds, in every case we know of (*8*), fall within the suggested range of *Carcharhinus leucas*. In Fig. 1*c*, we have compared it to those reported for other fishes (*7*). Any apparent discrepancies between our results and those of Lowenstein and Roberts may be attributable to the normal differences which might be expected between results from whole, living animals and isolated preparations and, of course, from two different though related species (*9*).

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26 January 1961

Perspective on Function of Free Space in Ion Uptake by Roots

Abstract. An observed effect of longitudinal flow rate through corn roots on phosphate transport is shown to be inconsistent with diffusion theory. R. C. Smith's results confirm rather the existence of a diffusion barrier between the xylem and the free space external to the central cylinder of the root.

Whether apparent free space in roots (the partial volume of the roots into which components of a solution appear to diffuse freely) extends to the xylem elements or is interrupted by a differentially permeable cell barrier (the endodermis) has been much disputed. As Russell and Barber (*1*) point out, the endodermis is regarded as a free-space barrier mainly on the basis of its structure, but there is no direct proof of such function. Since recent findings (*2*) would appear to assign free space to cell walls and intercellular space only (and not to the cytoplasm), the suberized Casparian strips of the endodermal cell walls could be an effective barrier to free diffusion and therefore could delimit the radial extent of free space into the root.

The increased solute absorption associated under some conditions with increased transpiration has been a major argument in favor of transport of solute by way of free space directly into the vascular tissues of the plant axis (*3*). Some 20 percent of the total water absorbed is believed to enter through free space together with the solutes it contains. An alternative explanation for the transpiration effect has been advanced (*4*). Solutes may accumulate in free space as water is differentially absorbed by cells bordering a free-space system that reaches uninterruptedly only as far as the endodermis. Absorption of solute from such higher concentrations in free space may, according to this theory, account for the transpiration effect.

Smith (*5*) has presented evidence for an effect of water movement through the vascular tissue on solute uptake which he believes occurred by simple diffusion through free space into the xylem. Young corn-root segments about 3 cm long were so mounted that nutrient solution lacking phosphate could be forced into one end of the root while nutrient solution containing isotopically labeled phosphate (1 mmole/lit.) bathed the outer surface of the root. The efflux was collected at the other end of the root, and its phosphate content was determined. Curves *A* and *B* (Fig. 1) show the relationships of phosphate concentration and total phosphate collected in the efflux to the rate of flow through the root. Contrary to Smith's conclusion, analysis of these data shows that the phosphate could not have moved directly into the stream flowing through the root by simple diffusion through free space. The equation for diffusion into a hollow cylinder is (*6*):

$$Q = \frac{2\pi D(C_o - C_i)}{\ln \frac{r_o}{r_i}} \quad (1)$$

where Q equals quantity diffused per second per centimeter of length, D is the diffusion coefficient in $cm^2\ sec^{-1}$, and C_o and C_i the concentrations outside the cylinder and inside it at some radius r_i respectively; r_o is the radius of the root, and r_i is the average radial distance of a system of sinks, the conducting elements of the xylem. For a given system such as a corn root, Q becomes simply proportional to $C_o - C_i$ and the remaining components can be lumped into a single constant k. Thus:

$$Q = k(C_o - C_i) \quad (2)$$

It is immediately apparent that the amount of phosphate recovered from the root was not proportional to the quantity $C_o - C_i$, because the concentration C_i decreased hyperbolically with increasing rate of flow through the root, but the phosphate collected increased linearly. This relationship does not conform to Eq. 2, which would require the amount collected to be a hyperbolic function of rate of flow just as the concentration of phosphate was. (The rate of flow has no direct bearing on Q. It affects it indirectly through its effect on C_i only.) Second, with 1 μmole/ml in the external solution and only 0.02 to 0.08 μmole/ml in the solution flowing out of the root, the value of $C_o - C_i$ would hardly be affected. No such large increase in the amount of phosphate collected could result from the very small changes in gradient. These qualitative conclusions may be assessed quantitatively as follows.

If the values are taken at the lowest flow rate, a C_i which rose to 0.076

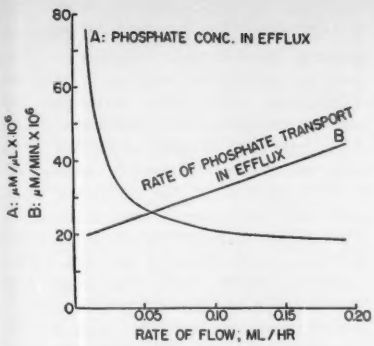

Fig. 1. Effect of longitudinal flow rate through the root on phosphate concentration found in efflux (*A*) and rate of phosphate transport by effluent stream (*B*). Graphs for apical corn root (*Zea mays* L.) segments from Smith (*5*).

μmole/ml yielded 20×10^{-6} μmole of phosphate per minute per root segment. The average C_1, rising from 0 to 0.076 as the solution flowed through the root was, therefore, 0.038 μmole/ml. Solving for k (Eq. 2) we obtain $k = 0.116 \times 10^{-6}$. With this value of k and the C_1 values read from curve *A* (Fig. 1) for different flow rates, the Q values were computed for each flow rate. These are given in Table 1 (on a per segment per minute basis) and demonstrate the very slight expected effect of the observed changes in C_1 on the diffusional transport of phosphate and also the hyperbolic character of Q as a function of flow rate. Diffusion into the flowing root stream, therefore, could not have been controlling the amount of phosphate recovered. One must conclude that phosphate was released into the flowing stream by a process that was proportional to some exponential function of the concentration in the flowing stream. Whether leakage or a more specifically controlled secretion of accumulated phosphate into the flowing stream was involved, this process and not diffusion through free space was the rate-limiting one for transport into the xylem.

Table 1. Theoretical effect of variations in C_1 on the amount of phosphate transported by diffusion across the root into the xylem.

Flow through root (ml/hr)	Phosphate theoretically transported (μmole/min per root segment)	Δ μmole/min / ml/hr
0.009	20.0	
		25
.025	20.4	
		4
.050	20.5	
		2
.100	20.6	
		0—
.194	20.6	

Now, what of the absolute magnitude of the diffusion process relative to the observed rate of solute transport? According to Eq. 1 and using a value for D of 10^{-5} cm² sec⁻¹, letting $r_0/r_1 = 5$ (actually the radius of the central cylinder is approximately one-third that of the root, so that the factor of ⅕ provides a safe margin), and letting $C_0 - C_1 = 1$ μmole/ml (actually ranging in this case from 0.96 to 0.99), we find that a cylinder 3 cm long should take up 7020×10^{-6} μmole of phosphate per minute. However, diffusion occurs through only about 7 percent of the cross-sectional area of corn roots [the effective radial pathways for an apparent free space for corn roots of 15 percent (*4*)], and the diffusional path is tortuous (being about 1.5 times the distance along a radius), so that we must multiply the value for an ideal cylinder by the fraction 0.07/1.5 to determine diffusion into the root segment. We would, therefore, expect an uptake of about 350×10^{-6} μmole/min per root segment compared to observed uptakes of 20 to 40, or an order of magnitude greater than was actually observed. It has been shown that equilibration of free space in bean roots is in good agreement with the diffusion equation when a normal diffusion coefficient of about 10^{-5} cm² sec⁻¹ is employed (*4*). The discrepancy in this case is large enough to suggest that the diffusion through free space is not the rate-limiting process in phosphate transport through the root.

Increased transpiration ordinarily causes an increased flow of water through the cortex. Smith's experiment is of particular interest because the technique employed allowed variation in the rate of flow through the xylem with little or no water-flow through the cortex. Instead, the movement of water through the xylem of the root was achieved independently of any movement of water or solution across the cortex. Regardless of the rate of water-flow through the root, diffusion alone, with essentially no mass flow, was responsible for the phosphate transport across the cortex to the central cylinder. This diffusion of course occurred, but diffusion was apparently stopped at some barrier, which then interposed its own concentration-sensitive mechanism for the release of phosphate into the stream of water moving through the vascular tissues. If Smith's results are not conclusive proof (a very rare commodity in any case) of the existence of a barrier to free diffusion in the root, they are at least very strong evidence for such a barrier.

Note added in proof: In a personal communication to one of us (L.B.), Smith affirmed belief in a barrier to free diffusion in the root, correcting an erroneous impression to the contrary given by his paper (*5*). The present analysis of Smith's data remains useful in refuting those who may still believe in a continuous free-space system leading into the conducting tissues of the plant.

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26 January 1961

Soil Mineralogy as Factor in Spread of Fusarium Wilt of Banana

Abstract. A correlation is established between the spread of *Fusarium* wilt of banana and soil mineralogy. Montmorillonoid-type clay minerals occur in all soils in which disease spread is slow, but, with the exception of two soils, this group of minerals is absent in soils in which it is rapid.

Fusarium wilt of banana, commonly called Panama disease, is caused by the soil-borne, root-infecting fungus, *Fusarium oxysporum* f. *cubense* (E.F.S.) Snyd. and Hans. The disease was first noted in Central America about 1900 and continues to be one of the main problems in the commercial production of wilt-susceptible banana varieties. The observation that the spread of the disease is not uniform in all soils resulted in the concept that soils differ in their "resistance" or "susceptibility" to the fungus (*1*). Early investigators classified banana soils as susceptible, semiresistant, or resistant (*1*), but current usage has modified these terms to short, intermediate, and long life, respectively. The effective banana-producing life of soils is determined by the rate of spread of the disease throughout a plantation and, from an economic point of view, is based on the length of time required for more than 50 percent of the plants there to show disease. Wilt-susceptible bananas can generally be produced on short-

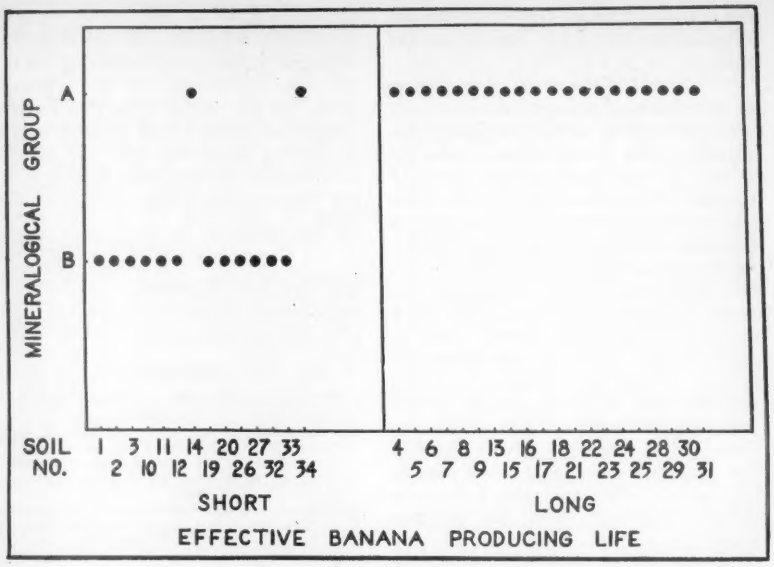
MINERALOGICAL GROUP
A
B
SOIL NO.
1 3 11 14 20 27 33
2 10 12 19 26 32 34
4 6 8 13 16 18 22 24 28 30
5 7 9 15 17 21 23 25 29 31
SHORT
LONG
EFFECTIVE BANANA PRODUCING LIFE

Fig. 1. Correlation between the effective banana-producing life of soils and soil mineralogy. Mineralogical group A contains montmorillonoid-type clay minerals, and group B does not.

life soils for 3 to 10 years, on intermediate-life soils for 10 to 20 years, and on long-life soils for more than 20 years. Some long-life soils have been in continuous banana cultivation for more than 70 years.

Not only is it of great economic importance to be able to predict accurately the potential life of soils, as large expenditures are required to convert virgin lands into plantations, but elucidation of mechanisms responsible for soil life may lead to methods for control of the disease in areas where it is now present. Potential banana lands in Central America are surveyed by a few individuals highly experienced in banana production and in evaluating banana soils.

Although the criteria originally used in these surveys were, for the most part, subjective, attempts have been made to correlate soil life with soil characteristics in order to obtain more accurate predictions (*1*). Of the many soil characteristics investigated (for example, texture, *p*H, total soluble salts, cation exchange capacity, available phosphorus, calcium, magnesium, and potassium, organic matter, and drainage), only the level of available potassium (*2*) showed a relatively good correlation with soil life (*1*, *3*). The long-life soils were usually high in available potassium, containing from 200 to 1000 parts per million, and the short-life soils contained from 30 to 200 parts per million. The level of available soil potassium has been implicated in a number of plant diseases, but no adequate explanations have been provided for this apparent relationship. Increasing the potassium content of short-life soils to that of long-life soils has consistently failed to extend the effective banana-producing life.

Because many soil characteristics depend upon the type and weathering sequence of the parent material, they may reflect only the type of clay minerals present in the soils. Inasmuch as clays have been shown to be involved in several microbial activities in soil, such as decomposition of organic matter (*4*), nitrification (*5*), nitrogen fixation (*6*), and adsorption of microbial products (*7*), they may also be important in the life of soils.

To determine whether effective banana-producing life is correlated with differences in the type of clay minerals, 34 soils were obtained from Honduras, Costa Rica, Panama, and Guatemala from banana plantations having different disease histories. These samples were analyzed mineralogically by differential thermal, x-ray diffraction, total potash, glycol retention, cation exchange capacity, and petrographic analyses. X-ray diffraction was the best method of analysis, because some soil factors, such as high levels of organic matter or $CaCO_3$, interfered with interpretation of the thermograms. Petrographic analysis was restricted to the 100- to 250-μ sand fraction and provided only an indirect index of the types of clay present. The other analyses were conducted to confirm the results obtained with the x-ray and differential thermal analyses.

With the exception of two soils, effective banana-producing life was correlated with types of clay minerals present in the soils (Fig. 1). There was no correlation between any of the other soil properties examined and disease history. Montmorillonoid-type clay minerals, present in all the long- and intermediate-life soils, were completely absent in the short-life soils, with the exception of soils 14 and 34. Preliminary attempts to separate intermediate- from long-life soils on a mineralogical basis were not successful, nor was there any correlation established between soil life and relative concentrations of clay minerals other than montmorillonoids.

The disease histories of the two short-life soils that contained montmorillonoid-type minerals are not well established. Soil 14, although located in an area surrounded by typically long-life soils, is formed from alluvium derived from two rivers, one of which deposits long-life sediments and one which deposits short-life sediments. The life of plantations on this mixed alluvium is, therefore, variable, and the sample used for mineralogical analysis may have been collected from a localized zone of long-life sediment. Soil 34 gave only a weak indication of the presence of montmorillonoids, and the disease history of the sample site is poorly defined. A good correlation between x-ray, differential thermal, and petrographic analyses was obtained with 15 soils analyzed by all three methods.

Concurrent with further studies to verify the correlation between the type of clay mineral and life of the soils, possible mechanisms responsible for the correlation are being investigated. Although emphasis is being directed primarily toward presumed clay-microbe interactions, possible clay-host relationships are also being considered.

The results obtained to date indicate that the potential banana-producing life of soils may be predicted on the basis of their clay mineralogy (*8*). It is hoped that this report will stimulate other investigations into possible relationships between soil-borne plant pathogens and soil mineralogy.

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Operant Behavior during Sleep

Abstract. Operant-conditioning techniques were employed to produce organized behavior during sleep as defined by the electroencephalographic record. Patterned responding was found in so-called "light" and "deeper" electroencephalograph stages as well as in the awake record. Results suggest that the use of the electroencephalographic record as a reliable indicator of the sleep-awakefulness continuum be re-examined.

The numerous investigations of the role of the reticular formation (*1*), and single-unit responses (*2*), in the modification of on-going behavior have led to several speculations about how the central nervous system subserves sleep. Of equal interest has been the problem that operative functions normally thought to be characteristic of waking behavior alone are present also in the sleep state—functions such as discriminative responses (*3*), integrative behavior, and control of on-going activity. The problem appears to be in the inadequacy of traditional behavioral and physiological indices to define a state of sleep. This report shows that complex behavior can be produced while physiological indicators, such as the electroencephalographic record, signal what has been defined as "deep sleep."

The experiments were done on five subjects ranging in age from 17 through 28 years. The subjects were tested weekly. The normal routine was for subjects to report to the laboratory on the night preceding the testing night. Suitable activities were provided during the intervening period, and the testing session was begun as closely as possible to each subject's normal bedtime hour. All subjects were thus deprived of sleep for about 36 to 40 hours.

Operant-conditioning techniques (*4*) were employed in the following manner. A microswitch was taped to each of the subject's hands, and two electrodes for administering shock were attached to the lower right leg. Whenever 3 seconds elapsed without a response on the left-hand microswitch, a pulse was delivered to the leg. By responding at a rate greater than once every 3 seconds the subject could avoid all shocks. A schedule of "time-out" periods, each of which followed a fixed number of responses (fixed ratio), was programmed on the right-hand key. During a time-out period, lasting either 5 or 8 minutes, all electrical equipment was turned off and the subject was allowed to sleep. The time during which avoidance and ratio-key responding were programmed constituted the scheduled activity period. Ten seconds before the end of a time-out period, a loud buzzer was sounded next to the subject's ear. The buzzer sounded continuously for 10 seconds and terminated with the appearance of the signal light mounted in front of the subject's head, initiating the next scheduled activity period. The first shock was delivered 3 seconds after the onset of the signal light unless the avoidance key was operated. This cycle of events was repeated continuously throughout the session.

Continuous electroencephalographic records were made from several scalp placements. The bulk of the data reported here was taken from bipolar placements of electrodes on the occipital center line. Parietal and frontal monopolar recordings were also obtained and were used in substantiating the various stages of sleep.

The scoring of the sleep stages followed a classification suggested by Dement and Kleitman (*5*) with some modifications. Stage 1A was taken as that portion of the record still exhibiting alpha bursts; stage 1B covered that part of the record between the last alpha burst and the appearance of the first 14-cy/sec spindle and consisted mainly of 3- to 6-cy/sec activity; stage 2 was characterized by spindle activity with low-voltage background, including some 3- to 6-cy/sec activity together with biparietal humps and K-complexes;

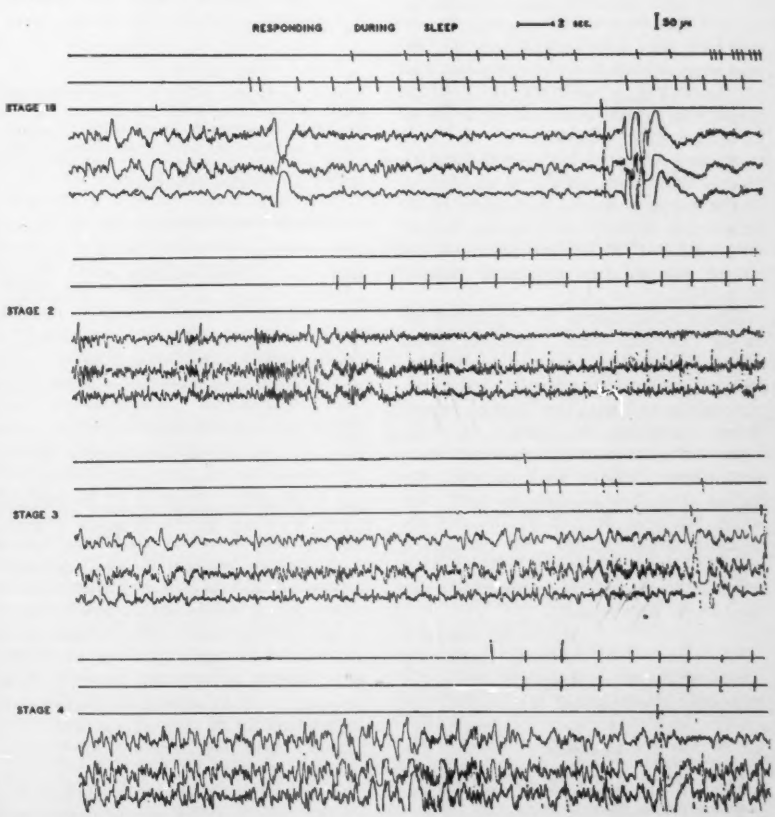

Fig. 1. Responding during electroencephalograph sleep. Stages are defined in the text. The six pens for each stage show from top to bottom: (i) fixed-ratio reinforcement responses, (ii) shock-avoidance responses, (iii) shock administration, (iv) occipital bipolar placement, (v) and (vi) occipital monopolar placements to the left-ear reference for monitoring. The examples of stages are taken from separate subjects.

stage 3 was signaled by the appearance of high-voltage slow waves (greater than 100 μv) with some 14-cy/sec spindling; stage 4 covered that part of the record where waves larger than 100 μv in the 1- to 2-cy/sec range occurred at a rate greater than two per 10-second sample of record.

The results showed in general that all subjects displayed an electroencephalograph sleep record and learned to respond appropriately on both microswitches without returning to the electroencephalograph waking state. Moreover, the data indicated that patterned activity could occur when the subject was in any electroencephalograph sleep stage, including stages 2, 3, and 4, although most of the evidence was accumulated from stage 1B. Figure 1 shows responding during the four stages of sleep as defined above.

Of particular interest is the occurrence of responding during the time-out periods. Such responding occurred in sequences lasting from 2 to 20 seconds and resembled the performance of the subject during normal activity periods in rate and pattern. All subjects exhibited this behavior, although its occurrence was relatively infrequent and was seen only in the early sessions. The corresponding electroencephalograph stage was classified as 1B or 2 in all cases but one. Behavior of this type may have occurred because the experimental conditions appeared ambiguous to the subjects in the beginning trials. In keeping with Jasper's notion, it may very well be that the subject must learn not to respond to "irrelevant stimuli" (*1*, p. 320).

These observations of organized behavior during sleep, together with studies involving discriminative responses previously reported, lend support to the idea that the "higher mental states" continue to operate at some level of the nervous system even during *deep* sleep. Perhaps such complex behavior does not require an alert and active brain as defined by the electroencephalograph record, but perhaps it may be that our means of assessing levels of sleep and concomitant activity need to be revaluated.

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25 January 1961

Control of Osmotic Pressure of Culture Solutions with Polyethylene Glycol

Abstract. Experiments with kidney beans indicate that Carbowax polyethylene glycol, molecular weight 20,000, upon purification, may be used as an agent to control the osmotic pressure of plant nutrient solutions without the hazard of interference with normal metabolic processes. With the sodium electrode and the thermocouple psychrometer, interaction between ions and Carbowax is shown to lead to a slight dissociation of the latter.

In the course of studies dealing with the aqueous environment of plant and animal organisms, it has become necessary to discern between effects due to the total level of solute (osmotic effects), and those due to the ionic composition at any such level (ionic composition effects). Only under conditions where an osmotic agent which does not interfere with normal metabolic processes is involved is it possible to separate osmotic effects from ionic composition effects.

In the present study, 13 different compounds were selected for examination on the basis of their chemical structure. A majority consisted of polymers used in the plastics industry. As a first step, the compounds were screened according to solubility or miscibility, viscosity, and resistance to chemical as well as biological activity. Subsequently, the compounds that passed these tests—dimethylsilicone (*1*), Elvanol 51-05 polyvinyl alcohol (*2*), polyvinylpyrrolidone NP-K30 (*3*), and Carbowax polyethylene glycols with molecular weights of about 4000, 6000, and 20,000 (*1*)—were investigated with regard to their effect on plant growth. Solution culture studies involving dwarf red kidney beans (*Phaseolus vulgaris* L.) indicated that all of the compounds were toxic when applied in their commercial form in concentrations equivalent to 1 atm of osmotic pressure.

The order in which the aforementioned compounds are listed is one of decreasing toxicity. In the case of Carbowax of molecular weight 20,000, spectrographic analysis (*4*) indicated the presence of large amounts of aluminum and magnesium. Purification of the polyvinylpyrrolidone and the two polyethylene glycols of highest molecu-

Table 1. Total fresh weight per plant of red kidney beans (average of four plants) grown in nutrient solutions containing either an excess of ions (in excess were the ions Na^+, Mg^{++}, and Cl^-; Ca^{++} and Mg^{++} were present in a ratio of 3:1, and the value of the ratio of Na^+ to $(Ca^{++} + Mg^{++})^{\frac{1}{2}}$ was 3.1 mmole$^{\frac{1}{2}}$ liter$^{-\frac{1}{2}}$ for all solutions) or one of three osmotic agents of high molecular weight [carbowax of molecular weight 20,000 (C20M) and 6000 (C6M), and polyvinylprrolidone (PVP), all purified by dialysis].

Osmotic pressure (atm)		Fresh wt (g per plant)			
		Osmotic agents			No osmotic agents
Ions	Osmotic agents	C20M	C6M	PVP	
		With osmotic agents			
1.4	0.5	86	54	62	
1.4	0.9	77	32	17	
2.5	0.5	64	43	42	
		With excess of ions			
1.9					83
2.3					72
3.0					63

Table 2. Properties of ionic solutions* of Carbowax polyethylene glycol of molecular weight 20,000 (C20M). Ca^{++} and Mg^{++} were present in proportions of 3:1, and the value of the ratio of Na^+ to $(Ca^{++} + Mg^{++})^{\frac{1}{2}}$ was 3.1 mmole$^{\frac{1}{2}}$ liter$^{-\frac{1}{2}}$ for all solutions.

Osmotic pressure (atm)		Mean activity coefficient of NaCl†	Osmotic pressure (% difference)‡	Relative viscosity (seconds of outflow)§	r_i
Ions	C20M				
1		0.92		9.5	
	1	1.03	+0	21.8	82
	2	1.08	+3	47.0	109
	3	1.25	+3	86.1	134
2		0.89		9.2	
	1	0.91	+2	21.0	82
	2	1.04	+4	46.4	111
	3	1.08	+3	82.2	134
3		0.87		9.4	
	1	0.94	+10	20.5	81
	2	1.08	+14	45.7	108
	3	1.11	+11	81.9	134

* The cations present were Na^+, Ca^{++}, and Mg^{++}; the anion was Cl^-. One atmosphere of osmotic pressure corresponds to solutions of about 0.024*N* NaCl or 0.032*N* $CaCl_2$. † As measured with the Beckman No. 78178V sodium selective electrode. ‡ The deviation of the osmotic pressure of mixed solutions of ions and C20M from the sum of the osmotic pressures of separate solutions of ions and C20M, as registered by the thermocouple psychrometer. § Of a 10-ml aliquot from 10-ml pipette.

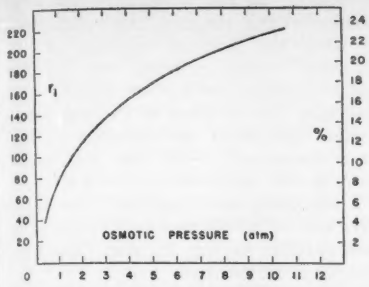

Fig. 1. The osmotic pressure of aqueous solutions of Carbowax molecular weight 20,000 as a function of the density in percent by weight, and the refractive index, r_1, of the solutions at 20°C (*12*).

lar weight—henceforth referred to as PVP, C6M, and C20M, respectively—was attempted by dialysis (*5*). Osmotically equivalent quantities of the purified products were dissolved in Hoagland's nutrient solution, which was diluted four times (Table 1). The magnitude of the aliquots taken followed from the relationship between the concentration and osmotic pressure of aqueous solutions (Fig. 1) as determined by the thermocouple psychrometer method (*6*).

The yield data indicate that nutrient solutions containing C20M produced slightly higher fresh weights of kidney beans than did isotonic solutions without C20M. This observation points to the absence of effects other than osmotic ones in the case of C20M. Less likely would be an alternative explanation implying that the C20M in the one case and the excess of ions in the other case exert an osmotic and ionic composition effect, the sum of which is of approximately equal magnitude. The lower yields, and the nonlinearity between osmotic pressure and yield, of plants grown in solution cultures containing dialyzed C6M and PVP, as compared to the yields of plants grown in isotonic solutions containing ions only, point to the physiological toxicity of these compounds.

An efflorescence of white material appearing on the upper surface of leaves of kidney beans grown in solutions containing C20M was shown by infrared analysis (*4*) to be identical to C20M. This finding suggests that C20M had passed through the plant system without undergoing any breakdown of its basic structural unit. Comparable transport of macromolecular substances through plant systems has been reported (*7*). These considerations, in conjunction with the existing knowledge on the structure of polyethylene glycols, render it improbable that C20M per se might exert any physiological effect on plant growth. The results of a more comprehensive experiment (*8*) support the viewpoint that purified C20M is physiologically inert to the extent that it can be used to control the osmotic pressure of plant culture solutions pending the effect of any interaction between ions and C20M.

Observations were made pertinent to this interaction. For this purpose, both ions and C20M were dissolved in concentrations equivalent to 1, 2, and 3 atm of osmotic pressure (Table 2). With the Beckman No. 78178V sodium selective electrode (*9*), the mean activity of sodium chloride was measured in the presence and absence of C20M, and mean activity coefficients were calculated. The results indicate that an increase in the concentration of C20M raises the mean activity coefficients of sodium chloride to well above unity. It is postulated that the large C20M molecules participate in a process of solvation. The ensuing arrangement of water molecules would accord a greater activity to the cations present. The occurrence of solvation would also explain why aqueous solutions of C20M do not observe Van't Hoff's law, complicating the freezing point depression method as a way of ascertaining the osmotic pressure of the solutions (see *10*).

The interacting effect of C20M on cations is, of course, mutual. This becomes at once clear from a comparison of the results of osmotic pressure measurements of mixed solutions of ions and C20M with the results of the corresponding separate solutions (Table 2). As the ionic concentrations were increased, the measured osmotic pressure of the ionic solutions of C20M appeared to be considerably in excess of the sum of the osmotic pressures of the separate solutions of C20M and ions. Under the same circumstances, the relative viscosity of the solutions decreased slightly for any one concentration of C20M. Both phenomena may be explained on the basis of an apparent dissociation of the long-stretched C20M molecule into shorter molecules of the same basic structure under the influence of ions, the decrease of the particle size of the solute being accompanied by an increase of the particle density of the solution. This feature complicates the use of C20M for controlling the osmotic pressure of plant nutrient solutions (*11*).

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3. Antara Chemicals.
4. We are indebted to Alton W. Specht, Spectrochemical Laboratory, Agricultural Research Service, U. S. Department of Agriculture, and R. T. Ambrose, Department of Chemistry, University of California at Riverside, for the spectrographic and infrared analyses, respectively, of samples of Carbowax.
5. Sacks prepared from cellulose casing, 5½ in. (inside diameter) (Visking Corp.) were filled with about 5 liters of a solution of the osmotic agent in water and suspended in running tap water for 10 days. Deterioration of the sacks due to chemical corrosion necessitated the exercise of extreme care in collecting the dialyzed solution.
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11. This report is a contribution from the U.S. Salinity Laboratory, Soil and Water Conservation Research Division, Agricultural Research Service, U.S. Department of Agriculture, Riverside, Calif., in cooperation with the 17 western states and Hawaii.
12. The relationship shown to exist between the osmotic pressure and the density of C20M solutions is accurately reflected by their refractive index, r_1. Measurements have shown that, for all practical purposes, the influence of ions and of temperature on the r_1 values of C20M solutions is negligible. Therefore, r_1 measurements constitute a simple and fast reference method for obtaining the osmotic pressure value of ionic solutions of C20M, for as far as due to this compound.

18 November 1960

On the Anomalous Activity of Thyroxin Analogs in Tadpoles

Abstract. The abnormally high thyroxin-like activity of certain thyroxin analogs is due to the use of the unique test route of immersion. When thyroxin, triiodothyronine, and their propionic and acetic acid analogs are tested by injection into the tadpole, their activities are more comparable to activity levels established in rat and man.

It has been frequently reported that certain side-chain variants of thyroxin (T_4) and triiodothyronine (T_3) showed many times the activity of thyroxin when compared for their ability to induce metamorphosis in anura (*1*). For example, the compound, 3,5,3′-triiodothyropropionic acid has been variously reported to be 200 to 300 times as active as T_4. However, the abnormally high activity of these T_4 analogs does not appear in T_4 activity comparisons in other in vivo or many in vitro systems (*1*, *2*). Thus the quantitative aspects of the tadpole response to certain T_4 analogs seemed to be unique.

Our continuing interest in the role of T_4 in general, and the biochemical aspects of anuran metamorphosis in par-

Table 1. Comparative activity of thyroxin and analogs. Data on rats, taken from Pitt-Rivers and Tata (*1*), are based on the oxygen uptake and goiter prevention tests.

Compound	Activity compared with thyroxin			Relative activity, injection/immersion †
	Rat (injection)	Tadpole		
		Rana grylio injection	*Rana* spp* (immersion)	
Thyroxin (T_4)	1.0	1.0	1.0	17
3,5,3′,5′-Tetraiodothyropropionic acid	0.1–0.6	3	21–100	1
Triiodothyronine (T_3)	1–10	17	5.0–20	‡
3,5,3′-Triiodothyropropionic acid	0.1–0.5	7	15–300	0.4
3,5,3′-Triiodothyroacetic acid	0.3–1.5	7	10–24	3

* Summary of experiments with several species, including *R. grylio*, *R. clamitans*, *R. catesbeiana*, and *R. pipiens*, taken from this report and from Pitt-Rivers and Tata (*1*). † Calculated from data as in Fig. 1. Considerable experimental variation was observed in this ratio. ‡ About 100.

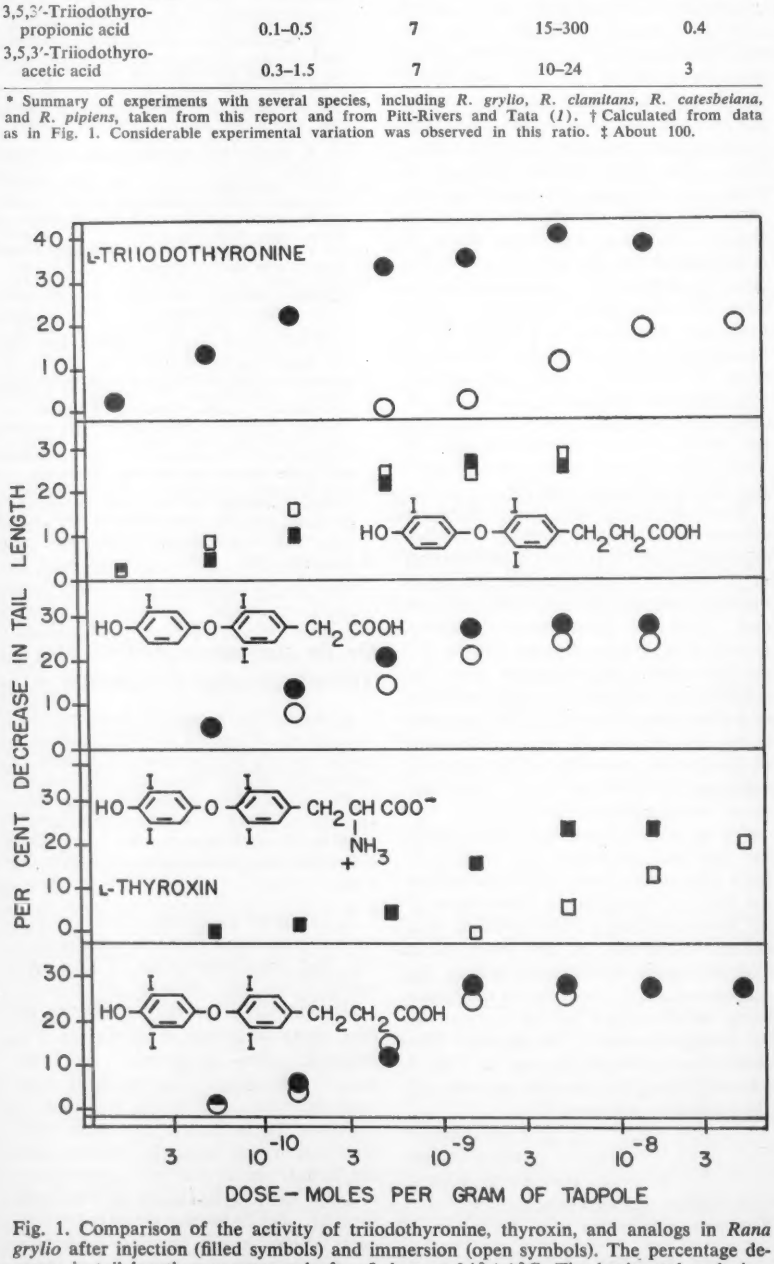

Fig. 1. Comparison of the activity of triiodothyronine, thyroxin, and analogs in *Rana grylio* after injection (filled symbols) and immersion (open symbols). The percentage decrease in tail length was measured after 5 days at 24°±1°C. The horizontal scale is a log-scale of the moles of compound given per gram of tadpole. In the immersion experiments the indicated dose of analog per gram of tadpole was dissolved in 500 ml of redistilled water containing 0.010*M* NaCl.

ticular (*2*, *3*), has prompted a reexamination of this question. Our conclusion is that the unusual activity of T_4 analogs in tadpoles arises from an unusual testing method—immersing the tadpoles in a solution of the test compound instead of the injection of the test compound. When the test compounds are administered to the tadpole by intraperitioneal injection, the relative activity of the various T_4 analogs is comparable to the in vivo activities found in rat or man.

Relative activities for five compounds tested by both immersion and injection in *Rana grylio* tadpoles are presented in Fig. 1. The most active compound is seen to be T_3 when injected, exceeding the activity of 3,5,3′-triiodothyropropionic acid and any of the other compounds tested. The activity of these compounds in *R. grylio* after immersion is in general agreement with previously reported data on other species (*1*). The most interesting feature of the data in Fig. 1 is the great disparity between activity of both T_3 and T_4 when tested by both routes. On the other hand, triiodo- and tetraiodothyropropionic acids show virtually the same activity regardless of the mode of administration. The activity of triiodothyroacetic acid is slightly higher after injection.

Similar data, not presented here, were obtained with two varieties of *Rana pipiens* by using the percentage decrease in tail height as the morphological criterion. The divergence between the activity of T_3 when tested by injection and immersion was not quite as large, but was still highly significant. It is important to note that the disparity between responses to T_3 and T_4 with the two routes of administration remains despite some variation in tadpole response due to seasonal and possibly other difficult to control environmental factors.

The response of the three different animals used in evaluating the five compounds is summarized in Table 1. It is clearly indicated that the tadpole immersion test yields the only unique data. When these compounds are injected, their activity is essentially comparable regardless of the test animal used. In the last column, the ratio of activity resulting from injection and immersion necessary for a 20 percent decrease in tail length is estimated from the data in Fig. 1. The figures vary from about 100 for T_3 to less than 1 for the propionic acid analog.

We are currently exploring the implications of the wide difference in the immersion and injected response to T_3 and T_4 by injection and immersion. Tracer experiments with labeled T_3, T_4, and propionic acid analogs are

planned. We are inclined to believe that the activity after injection gives a more accurate picture of the comparable T_4-like activity of T_4 analogs in the tadpole using the tail response. Activity comparisons should also be made using other criteria, for example, limb eruption and growth (*4*).

The tadpole response after immersion is probably strongly influenced by relative rates of penetration. Absorption undoubtedly occurs through the skin and the gills, since tying off the gut did not influence the response of the tadpole to T_3. It is consistent with the classical rules of permeability that a compound with only an acetate or propionate side chain would be more permeable than a compound with a divalent alanine zwitter ion side chain. Immersion tests might also be more subject to difficulties arising from the instability of compounds (*5*) and to adsorption on glass at high dilutions (*6*). Finally, it should be added that the results may help to explain certain enhancements and inhibitions of the tadpole response in immersion experiments (*7*). The many varied and confusing results obtained in this latter area may be due to effects on the permeability of T_4 and T_3 rather than representing an effect on the peripheral tissue response to the tryroid hormone (*8*).

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References and Notes

1. For a rather complete summary of much of the data on the relative activity of T_4 analogs, see R. V. H. Pitt-Rivers and J. R. Tata, *Thyroid Hormones* (Pergamon, London, 1959).
2. Only one example is cited here, that is, E. Frieden and R. T. Flitman, *Arch. Biochem. Biophys.* **64**, 513 (1956).
3. For a recent paper in this series see A. E. Herner and E. Frieden, *J. Biol. Chem.* **235**, 2845 (1960).
4. The recent experiments of J. Kollros *et al.*, presented at the annual meeting of the American Institute of Biological Sciences, Stillwater, Okla., on 29 August 1960, suggest that certain skin and other responses may be more sensitive to extremely low doses of T_4 in the hypophysectomized tadpole. Since the tadpole was immersed in the T_4 solution, it is possible that the skin and related structures received a relatively larger proportion of the very dilute hormones used.
5. Problems regarding the stability of T_4 and analogs have been mentioned recently by W. L. Money, R. I. Meltzer, J. Young, and R. W. Rawson [*Endocrinology* **63**, 20 (1958)] and by N. R. Stasili, R. L. Kroc, and R. I. Meltzer [*ibid.* **64**, 62 (1959)].
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8. This work was aided by a grant, C-3006, from the U.S. Public Health Service. A report of this work was included in a symposium on metamorphosis at the AIBS meeting, Stillwater, Okla., 29 August 1960.

6 February 1961

Nature of "Sex-ratio" Agent in Drosophila

Abstract. Several lines of evidence implicate small spirochetes, presumably treponemata, as etiologic agents in the production of the maternally transmitted "sex ratio" condition (SR) in *Drosophila nebulosa*, in *D. willistoni*, and in strains of *D. melanogaster* into which the SR condition has been artificially transferred. The presence of treponemata in the hemolymph of adult females of these species is completely correlated with the production of unisexual progenies and like this condition is dependent on the genotype of the host and of the infectious agent.

A condition of unisexual (or near unisexual) progenies in *Drosophila* known as "sex-ratio" (SR) has been intensively studied in a number of species by several investigators (*1*) who showed it to be maternally transmitted and dependent on an agent variously interpreted as a plasma gene, cytoplasmic particulate, or virus (*2*). The pattern of transmission has been established in *D. bifasciata, D. equinoxialis, D. nebulosa, D. paulistorum, D. prosaltans,* and *D. willistoni* (*3*), and in all except the first it has been shown that the stability and persistence of the condition is also dependent on the nuclear genotype of the flies. In *D. bifasciata* and *D. equinoxialis* this condition has been shown to be temperature sensitive and subject to thermic cure (*4*). The unisexual progenies are a consequence of disturbances of development in male zygotes which lead to 50 percent egg mortality (*5*). The pattern of disturbance and the stage of onset are strongly influenced by the genotype of the zygote, and there is evidence that female as well as male zygotes may be affected (*6*).

That the "sex-ratio" agent is of an infectious nature (even though the condition is not contagious) was demonstrated in experiments in which the condition was transferred by injection of ooplasmic materials from SR strains into previously normal strains of *D. willistoni* and *D. equinoxialis* (*7*). In the course of such experimental infections the condition makes its appearance after an incubation period of 10 to 12 days in many or all of the infected females. In some instances the condition may only make its appearance in later generations after a period of latent transmission (*8*). A thorough study of the course of several such infections showed that the otherwise normal daughters of injected females may transmit a sporadic and nonspecific zygote lethality which can be carried through more than 20 generations of their descendants (*9*).

A study of the distribution of the "sex-ratio" agent in tissues and organs of SR adults of *D. willistoni* demonstrated its presence in ovary, fat body, flight muscle, and in exceptionally high concentration in hemolymph (*10*). The agent was also found in high concentration in the hemolymph of the rare surviving sons of SR females in this species. Further, the agent may be present in latent form in flies of apparently normal strains of *D. willistoni*, as shown by infections produced from injections of extracts of such flies into other females of the same strain. Attempts to separate and concentrate the infective agent of *D. willistoni* by centrifugation and ultrafiltration of extracts of flies showed that the activity (as measured by frequency of infections) of supernatant fluids from whole-fly homogenates is not reduced on passage through a Millipore filter of pore size 0.3 μ, but is cut to about one-third by passage through a Millipore filter of pore size 100 mμ (*11*).

Microscopic examination of the hemolymph of females of *D. nebulosa* and *D. willistoni* giving strictly unisexual progenies shows the regular presence of many very fine filaments which are more numerous in older than in newly emerged flies. These filaments, which are absent from the blood of normal females of both species, are in constant motion in fresh preparations of hemolymph mounted in Crown immersion oil. They are visible only with dark-field or phase-contrast microscopy and in thin preparations can be seen to be of the order of 0.1 to 0.2 μ in diameter and to average 4 to 5 μ in length, although occasional individuals may be 8 to 10 μ in length. In favorable freshly mounted preparations, waves of sinusoidal or helicoidal movement are seen to pass along the length of the filaments, giving them a regular spiral appearance. In such preparations the filaments remain visible and active up to 48 hours at 25°C, although they become increasingly granular and fuzzy-edged, and evidences of spiralizing vanish. During this time there is an increase in the number of minute granules free in the hemolymph. At the end of a week's time the hemolymph preparations contain principally such small granules, evidently derived from the filaments. The granules appear to have a minute, almost invisible, tail or flagellum and maintain an active movement distinguishable from Brownian movement. Similar small active granules are numerous in the blood of rare surviving sons of SR females. Occasional granules of this sort are encountered in the hemolymph of most normal females and males.

The most satisfactory permanent preparations have been obtained by fixation of small drops or smears of

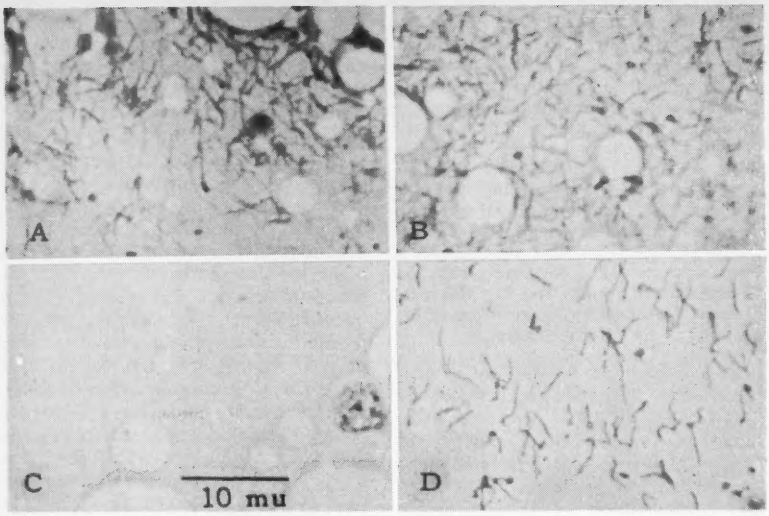

Fig. 1. Hemolymph smears from SR and normal females. Giemsa stain, phase contrast, scale for all photos is given in (*C*). (*A* and *B*) *Drosophila nebulosa*, SR strain PV-45, fixed in formaldehyde vapor, showing numerous spirochetes. (*C*) *D. nebulosa*, normal strain PV-59, no spirochetes; clear areas indicate fat droplets; small blood cell nucleus at right. (*D*) *Drosophila melanogaster*, SR strain (XXY) derived by transfer of SR from the SR B-3 strain of *D. willistoni*; fresh Giemsa preparation without fixation; spirochetes somewhat swollen and well stained.

hemolymph in formaldehyde vapor followed by one or another of the standard staining procedures (*12*). The filaments stain a strong purplish-red with Giemsa, are intensely colored by Fast Green employed as a basic protein stain, and are moderately colored by Azure B under conditions of ribonucleic acid staining. The filaments are Gram-negative, but give indications of slight Feulgen positivity. They blacken readily with Fontana's silver method. Their characteristic appearance in Giemsa preparations is seen in Fig. 1.

The filaments are sensitive to penicillin and rapidly disappear from the hemolymph of SR females injected with penicillin G. However, they reappear after a few days in the absence of further injections of penicillin. Normal hosts injected with penicillin-treated SR blood produced no SR progeny, while controls gave 100 percent SR offspring. Filaments were completely absent in the former and invariably present in the latter. The filaments have all the characteristics of small spirochetes and resemble those of the genus *Treponema* more closely than any other described forms (*13*).

Further evidence of the correlation between the "sex-ratio" condition and the presence of treponemata derives from experiments in which the condition was transferred from *Drosophila willistoni* into *D. melanogaster* (*14*). There, as in the original form, all females producing unisexual progenies possess the treponemata in their hemolymph. Where loss of the unisexual condition has occurred the spirochetes are lacking. The stability of the condition in *D. melanogaster* is dependent on genotype and, in some instances at least, on temperature.

Although apparently different from a larger spirochete described by Chatton in 1912 from *D. confusa* and named by him *Treponema drosophilae* (*15*), the rare occurrence of giant forms in the blood of very old flies (especially in *D. nebulosa*) does raise the question of a possible relationship. Since it has been demonstrated that the "sex-ratio" agent, and thus spirochetes, may be carried in latent condition, the whole subject of interrelationships of spirochetes and *Drosophila* deserves thorough investigation.

It is concluded that the "sex-ratio" condition in *Drosophila* species is a consequence of a very special, stabilized relationship between spirochete and host in which the genotypes of both are of prime importance (*16*).

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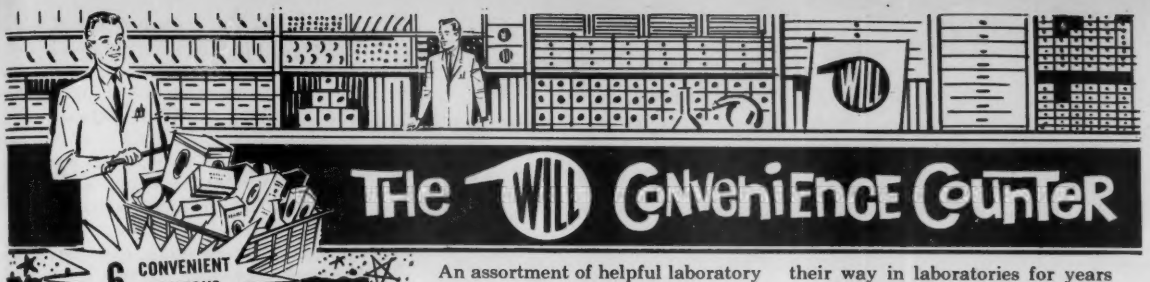
16. The research was supported by grant No. 6017 from the National Science Foundation.

22 December 1960



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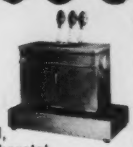

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The recent spectacular advances in cardiac surgery have resulted from the intimate and fruitful collaboration of the surgeons with embryologists, pathologists, internists, pediatricians, physiologists, and engineers. The present volume summarizes the current status of knowledge of congenital heart disease, ranging from the experimental production of developmental anomalies, through the morphology and pathologic physiology, to the diagnosis and surgical repair of congenital lesions, and includes an introductory chapter by the dean of cardiac embryologists, Professor Bradley M. Patten.

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Meetings

The Teaching of Chemistry

A seminar on "The Status and Development of the Teaching of Chemistry" was held in June 1960 in Greystones, Ireland, under the auspices of the Office for Scientific and Technical Personnel of the Organization for European Economic Cooperation (OEEC). It was attended by delegates from Austria, Belgium, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxemburg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States. The U.S. representatives were J. A. Campbell (Harvey Mudd College, Claremont, California); L. E. Strong (Earlham College, Richmond, Indiana); Robert Rice (University of California, Berkeley); and Paul Westmeyer (University of Illinois, Urbana).

The seminar made recommendations to the OEEC as follows.

1) Three *ad hoc* committees (*A*, *B*, and *C*) should be set up on an international basis, each committee to consist of six to eight members—university teachers, secondary school teachers, and school inspectors from the various member countries.

Committee *A* would examine the developments in theoretical chemistry in the light of their pertinence to secondary school teaching and of reports from the seminar and comments received on them from member countries. It would then draft the outline of a modern syllabus of chemistry suitable for secondary schools of the member countries. This syllabus would be expanded by explanatory notes and would be published by the OEEC as a manual or handbook for teachers of chemistry in secondary schools.

Committee *B* would undertake a similar task in relation to practical applications and would extend the manual to cover laboratory and demonstrational experiments.

Committee *C* would examine the matter of training and retraining of teachers of chemistry at secondary school level, with a view to establishing machinery to insure an adequate supply of teachers conversant with modern scientific developments and capable of teaching a course based on modern concepts.

2) Chemistry students should have, at all stages of instruction, the necessary background in physics and mathematics. It was recommended that courses in physics (in particular, introductory electricity) and mathematics (through elementary solid geometry) precede the introduction of chemistry.

While it was conceded that teaching of physics and chemistry by the same person in courses at the introductory level is desirable, it was emphasized that specialist teachers of the two subjects are required at the more advanced levels of secondary school teaching. It was agreed that much coordination in mathematics, physics, and chemistry courses could be achieved through cooperation of teachers in the planning stage.

3) Instruction in the following areas is basic to the teaching of chemistry at all levels and should be particularly emphasized at the higher levels in secondary schools: atomic structure and electronic theory of valency, chemical equilibria, and energy in chemical reactions. Presentation (particularly in courses on inorganic chemistry) of disconnected factual data unnecessary for illustrating underlying principles should be eliminated.

4) Practical work, both demonstrational presentations to illustrate lessons on theory and experimental work by students in the laboratory, is essential to the proper teaching of chemistry at all stages and should be included in the secondary school program.

5) The OEEC might recommend to member countries who operate a national syllabus and examination that certain designated schools be permitted to teach, on an experimental basis, approved courses not included in the syllabus.

6) In view of the importance of teacher retraining programs to provide teachers for the modernized course in chemistry, the OEEC should discuss with the suitable authorities in the various member countries means of promoting and financing extensive retraining programs.

A final report on the seminar is scheduled for publication in late spring.

MAX HELLMANN
National Science Foundation, Washington, D.C.

Forthcoming Events

June

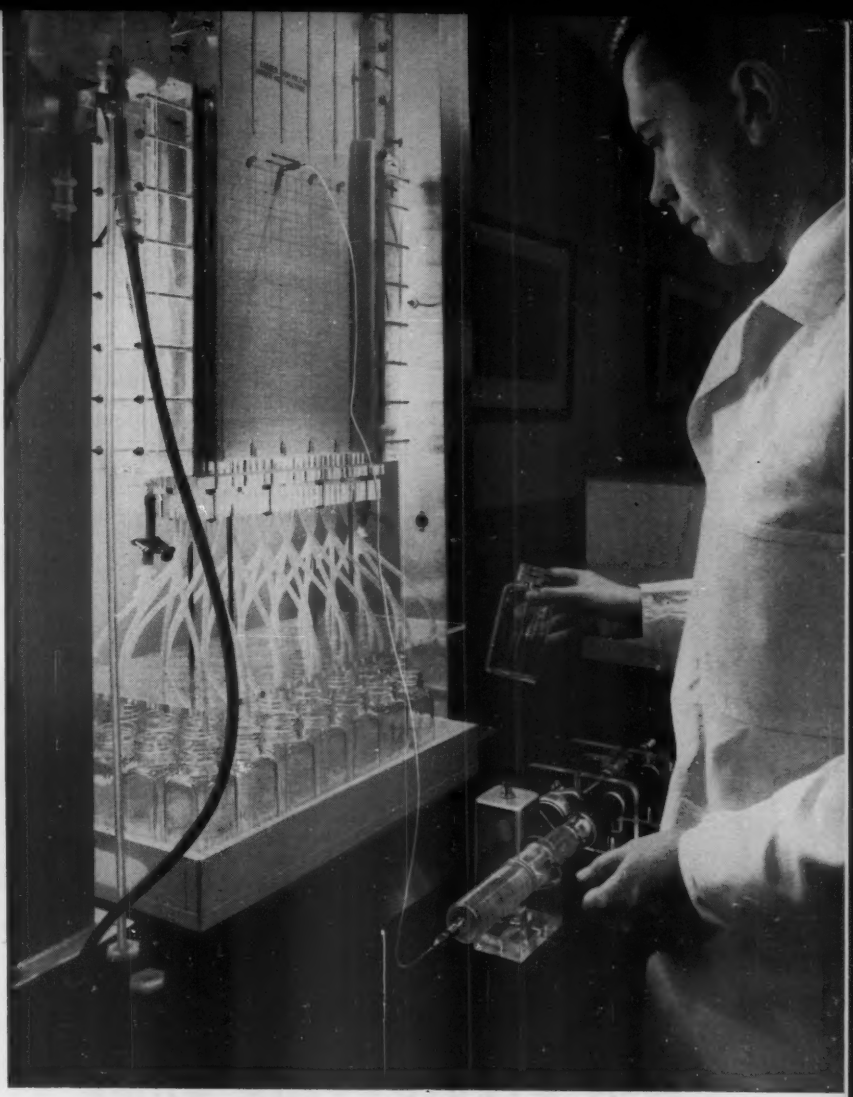
2–3. Canadian Soc. for Clinical Chemistry, annual general meeting, Guelph, Ont. (C. R. Cameron, Ontario Veterinary College, Guelph)

2–5. Latin-American Congress of Physical Medicine, Lisbon, Portugal. (C. Lopez de Victoria, 245 E. 17 St., New York, N.Y.)

3–11. Medical-Surgical Film Festival, 4th intern., Turin, Italy. (Minerva Medica, Corso Bramante 83–85, Turin)

4–9. Mass Spectrometry, ASTM Committee E-14, Chicago, Ill. (G. Crable, Gulf Research Center, P.O. Box 2038, Pittsburgh 30, Pa.)

4–10. World Congress of Psychiatry, 3rd, Montreal, Canada. (A. Roberts, Al-



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4–12. Cellular Regulatory Mechanisms, 26th Cold Spring Harbor Symp. on Quantitative Biology, Cold Spring Harbor, N.Y. (A. Chovnick, Long Island Biological Assoc., Cold Spring Harbor)

5–7. American Soc. for Quality Control, Philadelphia, Pa. (W. P. Youngclaus, Jr., 161 W. Wisconsin Ave., Milwaukee 3, Wis.)

5–7. Fundamental Aspects of Radiosensitivity, symp., Upton, N.Y. (A. H. Sparrow, Brookhaven National Laboratory, Upton, L.I.)

5–8. International Instrument-Automation Conf. and Exhibit, Instrument Soc. of America, Toronto, Canada. (I.S.A., 313 Sixth Ave., Pittsburgh 22, Pa.)

5–9. Animal Reproduction, 4th intern. cong., Amsterdam, Netherlands. (Secretariat, Burgemeester de Monchyplein 14, The Hague, Netherlands)

5–9. Effects of Ionizing Radiation on the Nervous System, symp., Vienna, Austria. (J. Burt, International Atomic Energy Agency, United Nations, New York, N.Y.)

5–10. International Colloquium on Spectroscopy, 9th, Lyon, France. (Secretariat, Groupement pour l'Avancement des Méthodes Spectrographiques, 1, rué Gaston Boissier, Paris 15)

5–16. Operations Research and Systems Engineering, Baltimore, Md. (Dean, School of Engineering, Johns Hopkins Univ., Baltimore 18)

6–8. Tissue Culture Assoc., 12th annual, Detroit, Mich. (F. E. Payne, Dept. of Epidemiology, Univ. of Michigan, Ann Arbor)

8–11. American Electroencephalographic Soc., Atlantic City, N.J. (G. A. Ulett, Malcolm Bliss Mental Health Center, 1420 Grattan, St. Louis 4, Mo.)

8–18. International Organization for Standardization, general assembly (members only), Finland. (American Standards Association, 70 East 45 St., New York 17)

9–11. Society of Biological Psychiatry, Atlantic City, N.J. (G. N. Thompson, 2010 Wilshire Blvd., Los Angeles 57, Calif.)

9–17. European Convention of Chemical Engineering, Frankfurt, Germany. (DECHEMA, Postfach No. 7746, Frankfurt/Main 7)

11–15. American Soc. of Mechanical Engineers, summer annual, Los Angeles, Calif. (O. B. Schier II, 29 W. 39 St., New York 18)

12–13. Radio Frequency Interference, 3rd natl. symp., Washington, D.C. (E. F. Mischler, National Engineering Service, Washington, D.C.)

12–14. American Dairy Science Assoc., Madison, Wis. (H. F. Judkins, 32 Ridgeway Circle, White Plains, N.Y.)

12–14. American Neurological Assoc., Atlantic City, N.J. (M. D. Yahr, Neurological Inst., 710 W. 168 St., New York 32)

12–14. Society for the Study of Development and Growth, regeneration symp., Williamstown, Mass. (A. C. Braun, Rockefeller Inst., New York 21)

12–15. Nature of the Real, conf., Milwaukee, Wis. (E. D. Simmons, Dept. of Philosophy, Marquette Univ., Milwaukee 3)

12–15. Physics of Electronic and Atomic Collisions, intern. conf., Boulder, Colo. (B. Bederson, Physics Dept., New York Univ., New York 53)

12–16. Association of Official Seed Analysts, Richmond, Va. (D. D. Forsyth, Agronomy Building, Madison 6, Wis.)

12–16. Molecular Structure and Spectroscopy, symp., Columbus, Ohio. (R. A. Oetjen, Dept. of Physics and Astronomy, Ohio State Univ., Columbus 10)

12–18. European Assoc. for Animal Production, 8th intern. cong., Hamburg, Germany. (European Assoc. for Animal Production, Via Barnaba Oriana 28, Rome, Italy)

12–24. European Inst. of Scientific Studies for the Prevention and Treatment of Alcoholism, Amsterdam, Netherlands. (D. Ehlbeck, Intern. Bureau against Alcoholism, Case Gare 49, Lausanne, Switzerland)

12–29. Statistical Quality Control Intensive Courses for the Chemical and Processing Industries, 18th annual, Rochester, N.Y. (H. M. Kentner, Extended Services Div., Rochester Inst. of Technology, Rochester 8)

13–14. Product Engineering and Production, 5th natl. conf., Philadelphia, Pa. (P. J. Riley, R.C.A., Building 10-6, Camden 2, N.J.)

13–16. Gas Chromatography Symp., 3rd biennial, East Lansing, Mich. (J. E. Callen, Procter and Gamble Co., Miami Valley Laboratories, P.O. Box 175, Cincinnati 39, Ohio)

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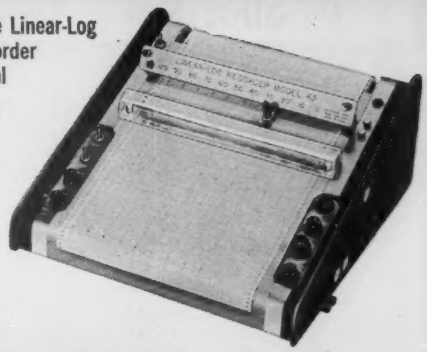

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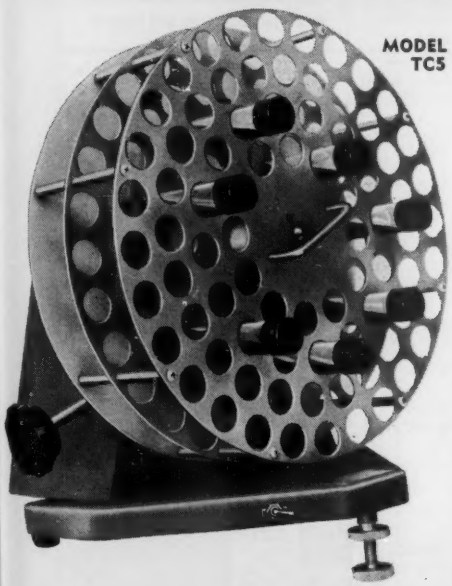

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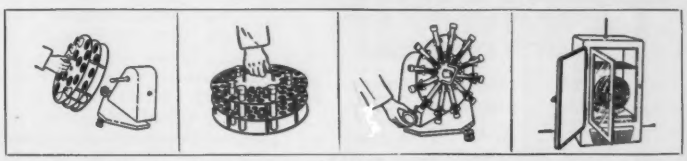

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13–16. Institute of Aerospace Sciences and American Rocket Soc., Los Angeles, Calif. (Inst. of Aerospace Sciences, 2 E. 64 St., New York 21)

13–18. Nuclear Congress, 6th, Rome, Italy. (Ufficio Stampa e Relazioni Pubbliche-CNEN, Via Belisario 15, Rome)

14–16. Applied Mechanics Conf., Chicago, Ill. (American Soc. of Mechanical Engineers, Meetings Dept., 29 W. 39 St., New York 18)

14–16. Semiconducting Compounds, conf., Schenectady, N.Y. (W. W. Tyler, General Electric Research Laboratory, Schenectady)

14–16. Theory of Weak and Strong Interactions, conf., La Jolla, Calif. (T. A. Manar, Scripps Institution of Oceanography, La Jolla)

14–17. American Assoc. of Bioanalysts, Dallas, Tex. (L. D. Hertert, 490 Post St., Room 1049, San Francisco 2, Calif.)

16–17. Meteoritical Soc., Nantucket, Mass. (G. L. Rowland, Long Beach City College, Long Beach 8, Calif.)

17–21. American Nuclear Soc., Boston Mass. (O. J. Du Temple, ANS, 86 E. Randolph St., Chicago 1, Ill.)

18–21. American Astronomical Soc., Nantucket, Mass. (J. A. Hynek, Dearborn Observatory, Northwestern Univ., Evanston, Ill.)

18–23. American Meteorological Soc., 193rd natl., and Pacific Div., AAAS, 42nd annual, Davis, Calif. (AMS, 45 Beacon St., Boston 8, Mass.)

18–23. American Soc. of Medical Technologists, Seattle, Wash. (Miss R. Matthaei, Suite 25, Hermann Professional Bldg., Houston 25, Tex.)

19–21. American Soc. of Pharmacognosy, annual summer meeting, Houston, Tex. (R. S. Westby, Eli Lilly and Co., 740 S. Alabama St., Indianapolis 6, Ind.)

19–21. Space Flight and Re-entry Trajectories, symp. by Intern. Acad. of Astronautics, Paris, France. (Secretariat, IAA, 12 rue de Gramont, Paris 2)

19–23. Conference on Carbon, 5th biennial, University Park, Pa. (Fifth Carbon Conf., Pennsylvania State Univ., Conference Center, University Park)

19–23. Current Aspects of Internal Medicine, postgraduate course, American College of Physicians, Iowa City, Iowa. (E. C. Rosenow, Jr., Executive Director, ACP, 4200 Pine St., Philadelphia 4, Pa.)

19–24. Feed Microscopy, annual meeting and special short course, Denver, Colo. (C. Jones, Colorado Department of Agriculture, 3130 Zuni St., Denver 11)

19–30. Astrophysics Seminar, Cloudcroft, N.M. (J. R. Foote, P.O. Box 1053, Holloman Air Force Base, N.M.)

21–1. International Plastics Exhibition and Convention, London, England. (British Plastics, Dorset House, Stanford St., London, S.E.1)

22–23. American Rheumatism Assoc., New York, N.Y. (F. E. Demartini, 622 W. 168 St., New York 32)

22–23. Computers and Data Processing, 8th annual symp., Estes Park, Colo. (W. H. Eichelberger, Denver Research Inst., Univ. of Denver, Denver, Colo.)

22–24. Endocrine Soc., New York, N.Y. (H. H. Turner, 1200 N. Walker, Oklahoma City 3, Okla.)

(See issue of 21 April for comprehensive list)

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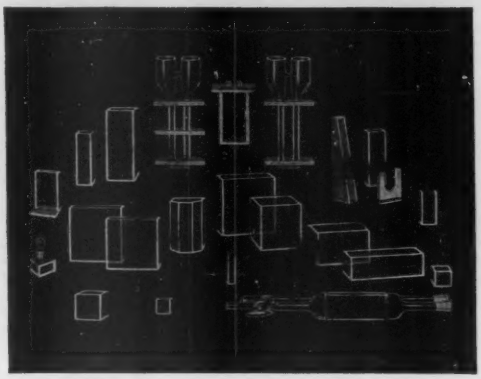

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Editor: Austin M. Brues

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